Making Service Design in a Digital Business

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Future-Focused Thinking

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Table of Content

– Volume 2 –

SECTION 4
Design EDUCATION AND LEARNING

– Volume 3 –

SECTION 5
AESTHETICS, COSMOPOLITICS AND DESIGN

SECTION 6
DESIGN AND TRANSLATION

SECTION 7

DESIGN FOR DESIGN – THE INFLUENCE AND LEGACY OF JOHN HESKETT

– Volume 4 –

SECTION 8

Design for Behaviour Change

SECTION 9

Design for Health, Wellbeing and Happiness

SECTION 10
DESIGN FUTURES

– Volume 5 –

SECTION 11
Design Innovation Management

SECTION 12
DESIGN PROCESS

– Volume 7 –

SECTION 16
DESIGN RESEARCH – HISTORY, THEORY, PRACTICE: HISTORIES FOR FUTURE-FOCUSED THINKING

SECTION 17
DESIGN-ING AND CREATIVE PHILOSOPHIES

SECTION 18
EMBODIED MAKING AND LEARNING

– Volume 8 –

SECTION 19
DESIGN FOR TANGIBLE, EMBEDDED AND NETWORKED TECHNOLOGIES

SECTION 20
Experiential Knowledge

SECTION 21
INCLUSIVE DESIGN

– Volume 9 –

SECTION 22
FOOD AND EATING DESIGN

SECTION 23
OBJECTS, PRACTICES, EXPERIENCES AND NETWORKS

SECTION 24
REFRAMING THE PARADOX – EXAMINING THE INTERSECTIONS BETWEEN EVIDENCE-BASED DESIGN AND DESIGN FOR THE PUBLIC SECTOR

– Volume 10 –

SECTION 25
SUSTAINABLE DESIGN

SECTION 26
THE POLITICS OF COMMONING AND DESIGN

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DRS2016
Design + Research + Society
Future-Focused Thinking

2016 Design Research Society
50th Anniversary Conference
27-30 June 2016, Brighton, UK

Editorial

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The 50th Anniversary conference of the Design Research Society is a special event at an interesting time for Design Research. The Design Research Society was formed in 1966 following the *Conference on Design Methods* held at Imperial College London in 1962. In the lead up to DRS2016 we contacted the secretary to the 1962 conference, Peter Slann, who now lives in Scotland, and who sent us the original reel-to-reel audio tape recordings of that conference. Listening to those tapes it is striking not only how similar some of the discussions are about design and design research, but also how much has changed. In 1962 every voice is a male British voice. One comment at the end of the conference stands out as significant. Thanking people for coming to the conference and looking towards the future at the end of the closing session, John Page, then Professor of Building Science at Sheffield University, asks the audience three questions (the quote is verbatim):

> "if one agrees that there are bodies of knowledge that have been raised here, which need further exploration – particularly a case in point would be the terminology of design – is there any point in trying to get some kind of inter-disciplinary working party going on these problems? In this question of disciplines, is there any machinery or any way of arranging for an interchange of information between specialists and people working at Universities? Lastly, is there any point in making the whole thing more of a formal entity, a society, or something of that kind?"

Fifty years later it is clear that there was a point. The DRS as it exists today can trace its origins to the affirmation of that last question in 1962, and the 'some kind of interdisciplinary working party' that Design Research has become owes its identity to that 1960's future-focused thinking.

Since the Conference on Design Methods in 1962 many Design Research conferences have been held, with the DRS often as a key organiser. Certainly in the earlier days, defined sub-fields of research originated from these conferences. Design Participation in 1971 started the participative design movement that has grown into present day co-design. Design for Need, held in 1976, and taking a global view of the population, started both sustainable and inclusive design, and Design Policy held in 1980 introduced a much needed social, political and international dimension to the design research field as Design itself lurched into the consumerist 80s.

From almost every conference comes a thread that leads to the present day, so the fiftieth anniversary conference represents a point to gather these threads together, see how they complement and blend with one another, and consider what kind of textile they might weave in the coming years. Indeed, the early advice that many gave was not to spend too much time looking back and to concentrate on the future. For DRS2016, as well as the Design Research field more generally, the increasing number of PhD researchers is a sign that this future is set to be a healthy one. A significant number of papers in these proceedings are the result of doctoral research projects and organisations like PhD by Design, who had a strong presence at DRS2016, ensure that today's PhD Researchers will become tomorrow's Design Research leaders.

The DRS Conferences have always looked to develop new formats for people to engage with one another, over and above the standard paper presentation. The 1973 Design Activities conference aimed at:

> "the provision of an extension of media forms beyond the normal 'verbalized' media of the average conference with the idea that such extensions were significant contributions to dialectical form, and not just 'entertainments'."

The 2014 DRS conference, in Sweden, continued that tradition by introducing 'Conversations' and 'Debates' alongside the more traditional academic paper presentation. It feels entirely appropriate that the field of Design Research is at the forefront of conference design, appropriating new technologies in developing more productive formats for discussion, networking, and presentation. And rightly so, because in an age when research papers and keynote presentations are available online we need to ask whether a conference, with all the travel, expense, and carbon involved, is still the most effective way of energizing and invigorating a research field.

DRS2016 is no exception and continues this ongoing conference prototyping activity. We have tried to develop a discursive conference that leans both towards the academic, in research papers, but also towards the practical in Conversations and Workshops. So this is a conference that presents existing research, projects, and discussions not as fixed end points, but as ongoing dialogue. To do that we have tried to balance the online conference with the offline one, and the ephemeral with the enduring. Partly this approach helps to provide a continued legacy for the conference, but it also helps to include as many people as possible in (re)directing the dialogical flow of research activity.

As an organising committee we met in January 2015 to talk about key questions, conference themes and conference design. From that discussion the three individual words of the DRS – Design, Research, and Society – were felt to define an interesting area for a conference; one that was about the practice and *doing* of design but also about design's societal impact and the moderating role that research plays between the two. Design + Research + Society perhaps represents a larger area than that of the Design Research Society, but as these proceedings demonstrate the appetite is clearly apparent for Design Research to embrace ever-wider concerns.

The underlying premise, however, was that 50 years of design research has provided us with a sound understanding of design and a solid foundation upon which to build. The interesting questions, then, appeared to us as not so much how we do more of the same – though that of course has its place – but in how we use what we now know. Hence the three broad questions that the papers in these conference proceedings respond to:

- How can design research help frame and address the societal problems that face us?
- How can design research be a creative and active force for rethinking ideas about Design?
- How can design research shape our lives in more responsible, meaningful, and open ways?

The DRS has a number of established Special Interest Groups (SIGs) which the organising committee thought important to prioritise but we also wanted to find a way to add additional emerging and complementary research themes to these. This resulted in a call for additional themes in June 2015 and a selection process that resulted in 15 further themes (from 25 proposals) alongside the 9 themes represented by the Special Interest Groups. The idea of a 'conference of conferences' began to emerge, with theme papers managed by sub-chairs, but consistency of peer-review overseen by a central review committee across all themes.

The systems currently available for managing paper submission, in the case of DRS2016 the excellent ConfTool system, now provide comprehensive integrative platforms to conduct sophisticated submission, peer-review, rebuttal, discussion, communication, and programming of papers, which means we can be more confident than ever about the academic quality of the final papers accepted for DRS2016. In total we received just under 500 paper submissions all of which were reviewed by two, and sometimes three reviewers, as well as being managed by theme chairs. In total 939 reviews were written by 290 reviewers with 200 papers being accepted, and a further 40 accepted following revision. This represents an acceptance rate of 49%.

The 240 papers in these proceedings have been grouped under 26 themes, 23 of which have been closely managed and developed by theme chairs (the other 3 themes derived from an Open Call). In these proceedings you will find an introduction to each theme by the relevant chair(s), outlining the background to the theme and putting the papers that were finally accepted and published into a wider context. Nine of the themes are the result of calls from the Design Research Society Special Interest Groups, which are active throughout the year and that report to the DRS council regularly. Many Special Interest Groups hold their own conferences, supported by the DRS, so the papers in these proceedings, responding to the overall theme of Future-focused Thinking, should be seen as a sample of those specialisms.

Fittingly for a 50th Anniversary conference there is a strong historical thread of papers – the field of Design Research now becomes a subject of historical study in the themes of *Histories for Future-focused Thinking*, *50 Years of Design Research,* and *Design for Design: The*

Influence and Legacy of John Heskett. This is a useful development, and shows the maturity of the field now, with early work not just a familiar citation in reference lists, but something that can be looked at in a wider cultural and historical context.

Many of the new themes bring a more critical and speculative approach to Design Research, framing research questions and practices in ways other than what some see as more 'traditional' evidence-based approaches to research. These are papers that argue for a particular position or approach to understanding design or practice. Examples of these themes include *Aesthetics, Cosmopolitics & Design*; *Design-ing and Creative Philosophies*, and *Reframing the Paradox: Evidence-based Design and Design for the Public Sector*. The emerging area of Social Design is well represented in the areas of *Design Innovation for Society* and *The Politics of Commoning and Design* and shows the importance of Design Research to discussing and achieving concrete outcomes for social good.

The idea and limits of Design and Design Research are explored in many themes, but in particular *Objects, Experiences, Practices & Networks*; *Design and Translation*; and *Design for Tangible, Embedded and Networked Technologies* take a more systemic view of design, placing it within a network of activities and technologies. In contrast to this other themes focus much more on the individual and collective experience of designers and others involved in the process of design, for example: *Experiential Knowledge*; *Embodied Making and Learning*; *Aesthetic Pleasure in Design*; and *Food and Eating Design*.

Of course there are themes that have been ever-present in DRS, and in other Design Research, conferences – understanding design process and the nature of design knowledge are the subject of the *Design Epistemology* and *Design Process* themes. The practical impacts that design can have on all types of organisations are explored in *Design Thinking*, an area of continued and increasing interest, and *Design Innovation Management*. *Design Education and Learning,* now with its own large biennial conference series, was the most popular theme for DRS2016, with 28 papers accepted from 53 submissions.

Finally, there are a set of well-developed themes, organised as part of DRS Special Interest Groups, that broadly explore the welfare of others both in a small and large sense embracing ideas of person-centredness, responsibility and ethics. These themes include *Design for Health, Wellbeing, and Happiness*; *Inclusive Design*; and finally *Sustainable Design.*

As in any research field the definitions between sub-areas often blur and overlap, and there are themes that contradict and conflict with one another, strongly arguing against a particular approach or theoretical grounding of another area. The DRS2016 keynote debates were designed to explore some of these issues and fault lines but more generally this should be taken as a sign of health and maturity. For many years we have heard that Design Research is a new field, still finding its feet, but as an organising committee we think the definition and extent of the themes in these proceedings demonstrate precisely the opposite. In Fifty years we have built up a strong and diverse research field that is widely applicable, broadly inclusive and, in 2016, more relevant than ever.

There is a sense in which design research sits at the crux of a false dichotomy; between on the one hand research in a ‘pure’ form (which values objectivity, subjectivity, experiment, discourse, history, analysis) and on the other the active engagement in shaping future forms by suggestion, prototype, speculation, practice, and intervention at all levels, from the molecular to the political, from the anthropological to the computational. In an increasingly fragmented and atomised world Design Research is a field which reveals the falsehood of the dichotomy. It is a field that collectively links disciplines, audiences, and technologies in a critical but productive way. The design of a conference – with its implicit value systems, partiality to statistical analysis, but with an emergent structure and representation – is no bad example of a future-focused design research that shares what knowledge is known and explores what knowledge is possible.

Finally, we would like to thank all people – the local organisation, the international programme and review committee, and all the reviewers – involved in organising DRS2016 and who have contributed to such a huge collective effort. The valuable time that has been given in helping to shape and deliver the conference has been very much appreciated. Thanks should also go to the Design Research Society, for supporting the conference so effectively; to the Royal College of Art and Imperial College London for providing time and resources as partner Universities; and to the University of Brighton, particularly the College of Arts and Humanities, for enabling the early vision of a 50th Anniversary DRS conference to be fulfilled.

Peter Lloyd
DRS2016 Conference Chair
Vice Chair of the DRS
Brighton, UK

Previous Design Research Society and Associated Conferences

1962 *Conference on Design Methods,* London, UK
1964 *The Teaching of Engineering Design*, Scarborough, UK
1965 *The Design Method*, Birmingham, UK
1967 *Design Methods in Architecture*, Portsmouth, UK
1971 *Design Participation*, Manchester, UK
1972 *Design and Behaviour*, Birmingham, UK
1973 *The Design Activity*, London, UK
1974 *Problem Identification for Design*, Manchester, UK
1976 *Design for Need*, London, UK
1976 *Changing Design*, Portsmouth, UK
1978 *Architectural Design*, Istanbul, Turkey
1980 *Design Science Method*, Portsmouth, UK
1982 *Design Policy*, London, UK
1984 *The Role of the Designer*, Bath, UK
1998 *Quantum Leap*, Birmingham, UK
1999 *CoDesigning*, Coventry, UK
2002 *Common Ground*, London, UK
2004 *Futureground*, Melbourne, Australia
2006 *Wonderground*, Lisbon, Portugal
2008 *Undisciplined!*, Sheffield, UK
2010 *Design And Complexity*, Montreal, Canada
2012 *Uncertainty, Contradiction and Value*, Bangkok, Thailand
2014 *Design's Big Debates*, Umea, Sweden

Volume 8

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SECTION 19

DESIGN FOR TANGIBLE, EMBEDDED AND NETWORKED TECHNOLOGIES

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Introduction: Design for Tangible, Embedded and Networked Technologies

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tentSIG is concerned with design as it deals with networked and embedded technologies. It seeks to complement the work of the Human-Computer Interaction (HCI) and Interaction Design research communities from a broader space of design research; in doing so, it also harbours the ambition to 'infect' design research with important theories and practices in these fields. We asked for contributors' critical reflections on new work concerned with perceptual qualities of networked and embedded technologies (in particular the tangible), with design methodologies for new materials and things (distributed, invisible, or emergent), and with a focus on the person at the centre of future networks (including implications for ethics in design and technology).

The special interest group was convened in early 2015, in conjunction with an international Arcintex research network workshop and symposium at Nottingham Trent University. DRS2016 is the SIG's first appearance at a Design Research Society conference, and we are very pleased to welcome a broad range of excellent submissions, organised around two key themes of data (its value, modalities, and availability to different stakeholders), and design strategies (including participatory methods, Service Design and User-Centred Design).

Data: its value, modalities, and availability to different stakeholders

Speed and Oberlander introduce an ablative framework for designing from, with and by data. They make the case that Human-Computer Interaction has been superseded by Human-Data Interaction as a result of cloud computing, social computing practices, and the rise of the Internet of Things (IoT). As such, fewer of our interactions are with recognisable computational devices, and increasingly with familiar things that happen to be embedded with wireless technology and sensors, and of course, with other people, in interactions which collect and generate data. This means that we interact less with objects (computers) and more with data flows, and that these interactions should now be the focus of design efforts. The ablative nature of the framework is drawn from the Latin grammatical structure that describes "an agent, instrument or source within a relationship": designing *from data* resonates with the research *for design* relationship; design *with data* resonates with research *through participatory design* practices, in which end users consider their own use of data flowing to them; while design *by data* describes a highly emergent, non-anthropocentric scenario, in which large data sets gathered in use, are analysed to autonomously generate new products and systems: data researches *into* itself.

The framework provides a crucial overview, allowing designers to organise existing methods, anticipate emerging methods, and recognise the performativity of data at work in different networks; as such, it both responds to and highlights the changing nature of design's role in "value constellations". This paper is followed by Hogan and Hornecker, who focus on the representation modality of data in tangible interfaces. In line with the previous authors' assertion that more devices and services are becoming data-centric, this research deals with users' experiences with data regarding indoor air quality, situating the 'design probes' in social home and office contexts of use. The work contributes to the growing field of non-screen based data representation, and considers sonification and physicalisation as output modalities in non-ambient, portable handheld objects. Wooden cubes with sound and vibration outputs were compared with the use and experience of a cube with a visual LCD display. In this work, data informs the creation of value around social interaction and personal space. Hogan and Hornecker note that before taking part in the design probe experiment, participants had not been concerned with indoor air quality, but began to pay attention to it through playful use of the objects.

The notion of attention is then taken up by Gullick and Coulton, who discuss the delivery of hybrid physical/digital information in the context of gaming. Game objects are evolving to support interaction with screen-based environments, storing player history, character types and characteristics in the physical object rather than on a console. This paper introduces research on the extension of the physical game object's potential to communicate information with the player during the game, and gives examples of the different possible interaction scenarios involving objects, screens and physical space. The authors introduce the concept of sensory 'Information Bandwidth' as a means to design according to how people perceive and interpret data through the whole body in interactive spaces. Gullick and Coulton take a craft-led participatory design approach to the generation of novel data representation objects, which include inflating balloons for in game information, and moving antenna on character objects. Darzentas, Hazzard, Brown, Flintham and Benford discuss how digital data associated with the ongoing use of objects in the IoT can become rich and meaningful when situated within communities of practice. Their paper introduces ways in which data is gathered, and is narrativised through provenance and use. Through working with gaming and music communities, they illustrate that the "mappings between interactive decorated physical things and their records are complex, multi-purpose…and need to be dynamically tunable to different owners and contexts". Questions of ownership are brought up, and opportunities for fictional stories, as well as verifiable accounts of provenance, are introduced as ways to enhance different types of value, while the availability of data within situated contexts of use is shown to pose challenges to established norms of practice.

Design strategies: participatory methods, Service Design and User-Centred Design

Jason Germany identifies an emerging semantic issue as devices establish multiple wireless ad-hoc relationships with each other. Where wires once served to visually and physically map and define such relationships, new forms of non-screen based symbolic systems are now needed. He asks if users can develop such frameworks through the shared formal characteristics of tangible objects, and shifts standard psychological perception study techniques towards generative design, in which people actively create their own meaning. Relationships seem to be definable based on proximity and the orientation of forms towards one another, though Germany points to the need for more work grounded in perception theory. If Germany deals with spatial relations, Stead's paper introduces the expanded embodied temporal potential of connected things through Sterling's concept of the spime. He introduces the 'toaster for life' as an example of a design fiction that avoids the spectacle of the utopian or dystopian vision, seeking to establish sustainability as an everyday concern in the near technological future. He discusses how crafting the toaster as a design fiction necessitates a critical review of the design process itself, and emphasises that design outcomes such as this should not be seen as 'solutions' to 'problems', but a means for generating discussion around particular issues, in this case, sustainable design in a connected world. To achieve this, the material spime has to be believable, and thus designed as if it is indeed real, going through several iterations, and assessed according to such strategies as for Design-for-Dissassembly and Design-for-Recycling. In this way, the speculative process is blurred with current commercial design processes, while seeking to generative ongoing reflection on design, through design.

The focus of design is extended to the complex socio-cultural ecosystems of digital service development by Rytilahti, Rontti, Jylkäs, Alhonsuo, Vuontisjärvi and Laivamaa. Through the use of three service design methods, they examine the pragmatism of a service design mindset, and how this helps to create new knowledge for socio-cultural process management, in tandem with technological systems development. The classical idea of knowledge as static is contested, and a discursive, active and shared perspective is introduced through the service design work, as a way of overcoming specialist silos of knowledge. The authors find that participating teams' commitment and motivation are noticeably increased through the tangibility and visibility of service design thinking processes, and that such tools offer not only classical research insights into customer values, but serve to make organisational structures and processes more transparent between internal teams. The playful aspects of design thinking are further developed by Frankel and Hrinivich in their study of 'serious play', as a creative strategy for generating wearable concepts. They propose aspects of serious play as ways to overcome the problems of fixation in designing novel, near-future technologies such as wearables, where designers may be overly influenced by known or existing product features. The participant design teams were often shy to act out scenarios, but used gestures and humour in a variety of ways to facilitate their own group cohesiveness, and to manage the introduction of less conventional design concepts. As a result, Frankel and Hrinivich suggest that design students are taught gestural skills, and the development of ways to involve less confident team members in such performative processes. The final paper of the session is also concerned with the development of wearable and e-textile concepts, and revisits the tangibility of Rytilahti et al's pragmatic approach, and discusses making tangible in two directions. The first of these is concerned with making the visions of near future technologies more accessible to diverse communities of end-users to enable their entanglement in co-creating desirable technological futures, while the second is concerned with making end-users more tangible and present for design teams and developers. In this case, the end-users in question are people with lived experience of mental health issues, who are accessing a third sector mental health service. As so many wearable and e-textile concepts are oriented around health and mental wellbeing, making real individuals' experiences more palpable ('tangible') is important, if we understand users to be configured at least in part by the design process.

In common with some of the other papers in these strands, the research described by Kettley, Sadkowska and Lucas treats users as experts, rather than designers, and the paper situates this attitude within the theory of the Person-Centred Approach. The co-development of two service-design toolkits is described, and in contrast to Rytilahti et al's 'silver set', an ad-hoc approach to aesthetic and materiality was found to facilitate inclusion with this cohort of participants, and was even seen to support humour and spontaneity in the description of sometimes emotionally difficult scenarios. Fanciful scenarios were mixed with pragmatic ones by the participants in imagining future uses and experiences with e-textile things, and the formal characteristics of the textile props provided were found sometimes to directly inform interaction concepts and experiences. In working with mental health service users, the researchers found that such individuals' voices were often overlooked or even actively mistrusted by the medical establishment, raising questions for service design and participatory design research practices, which normally try to enable transparency of the power relations between stakeholders. The authors found that different audiences were looking for different forms of 'evidence' from the research, and describe the making of three short films with participants, to present personal experiences as research outcomes, and make those individuals more visible (tangible) to research communities.

The themes that got away

These themes were not predefined, but were strongly suggested by the submissions we received. Demonstrating the breadth of possible approaches to design for tangible, embedded and networked technologies, a further three papers examine in detail User-Centred Design as it meets Service Design in the domain of wearables (Liao, Chou and Hung), the relationships between materiality and intuition in mixed reality systems (Desai, Blackler and Popovic), and the challenges to materiality at the intersections of design and ubiquitous computing posed by nanotechnology (Paiva); if the themes of the SIG were rearranged, we could indeed frame submissions according to user communities and demographics (for example children), or (im)materiality and presence in hybrid systems. The richness and diversity of the papers here have led us to consider themes that would be interesting to foreground in future tentSIG events, and we welcome suggestions on our ideas around: visibility and the potential for things to be configured and 'brought into play' by users (in Latour's terminology); different modalities of understanding and being-with technologies, for example, cognitive and experiential approaches within the design process; how we research users 'in the wild'; and modalities of data, concepts, and relationships and associations between things. We thank all of our authors at DRS2016, and look forward to continuing such discussions with you into the future.

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Designing from, with and by Data: Introducing the ablative framework

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Abstract: This paper introduces a framework for designers in which existing methodologies can be placed in order to better acknowledge how they work with data in different ways to support their practice. The paper starts by distinguishing three kinds of value associated with data: (i) raw measurements; (ii) commercial and social; and (iii) moral and ethical. We then note that changes in computing and communications technologies serve to de-emphasise computers as devices, and re-emphasise the flow of data between people, machines, and things; thus, we share the view that human-data interaction is a key challenge for designers. In addressing the challenge, we introduce the framework for designers to distinguish design *from*, *with*, and *by* data. We note that informatics provides the theory for, and technologies of, information processing, while design provides the methods to adapt and create products and services. The paper uses case studies to illustrate our approach.

Keywords: design, data, informatics, framework

1. Introduction.

Design has used qualitative and quantitative data to inform the development of products, services and systems for many years. From market analytics to observational analysis, and questionnaires to design probes, designers understand implicitly the need to watch, listen and learn from the data that is gathered by prototypes before and during the design process. However, whilst the methods for gathering data have grown to reflect research through design approaches, there has been little classification of the kinds of data that we are encountering in an age of big data, nor to frame how we design alongside it.

This paper introduces a framework for designers to reflect on their existing methods of working with data, in order to anticipate its ability to transform design process as its level of performativity increases. The paper begins by outlining three kinds of value that data is involved in mediating and then establishes a complexity in which qualitative and quantitative data becomes entangled across social, economic, moral and ethical values. The second part of the paper introduces an emerging field of enquiry that supersedes Human Computer Interaction, that of Human Data Interaction (HDI). HDI demands that serious attention is now required to address the systems that place stress on conventional ethical and moral models of handling personal data. Our paper takes this mantle and proposes that designers play a vital role in the design of future systems in which people, things and computers co-exist in the production of data.

However, in order to understand better how to design alongside data, the authors go on to introduce a framework for recognising how existing and emerging research methods address the increasing performativity of data. The paper closes with reflections on the three cases of designing from/with/by data, and then explores the implications for the framework.

2. Data involves at least three kinds of value.

A collection of data can be thought of as a set of values for some variables, acquired originally by measurements of some kind. Under an appropriate interpretation, data counts as information, and information processing can refine (relatively) raw data and make it useful, by capturing, transforming and communicating it.

In the past, and still today, almost all data is impersonal; measurements in the Large Hadron Collider, or in the Square Kilometer Array aim to provide extraordinary numbers of values for variables every day. Of course, in the past, at least some data was personal, as in population censuses. However, an increasing amount of data is personal. That is, because their preferences, attitudes and behaviour can be measured online in many ways, people nowadays generate lots of data, both consciously and unconsciously. This “big data” of a personal nature captures aspects of their behaviour as consumers, communicators, and as healthy or unhealthy physical and social beings.

So the first set of values, the data values that are mere measurements, can become entangled with two other important kinds of value.

The second kind of value arises because by aggregating any kind of data at scale, corporations and agencies can generate new commercial or social value: they can create products and services which increase individual or collective utility, and which can be monetised in at least some cases.

The third kind of value arises because the ways in which corporations and agencies treat all kinds of data (but especially, personal data) reflects a set of moral or ethical values, including: the protection or violation of privacy; the promotion or prevention of reciprocity in relationships; respect or rejection of the customs and attitudes of less powerful peoples– such as their attitudes to time, diet, or sexuality; and the enhancement or erosion of fairness in societies most generally.

3. The fall of computers and the rise of data

The pervasiveness of the internet, and of wireless networking, have enabled widespread adoption of cloud computing services. For our purposes, what matters about the cloud is that it opens up gaps between the places where data is generated, processed, and acted upon. In the past, the capture, transformation and communication of information might all have happened in one place on one material device: a computer with suitable peripherals. Now, we frequently do not care where the computing takes place. In light of this, some aspects of human computer interaction are better framed in terms of human *data* interaction. If human computer interaction studies the ways in which humans interact with, and through, computers, we might now de-emphasise the material devices doing the computing, and focus more attention on the ways in which humans interact with, and through, data.

One group of researchers concerned with the processing of personal data have already used the term "human data interaction" to cover the "the individual and collective decisions that we make and actions we take, as users of online systems, or as subjects of data collection practices" (Mortier et al. 2014). They point to the need to "make data and analytics algorithms both transparent and comprehensible to the people the data and processing concerns", and to give people "the capacity to act within these data systems, to opt-in or to opt-out, to control, inform and correct data and inferences". On this account, the proper study of human data interaction goes well beyond traditional interests in data visualisation, to explore social, legal and ethical aspects of personal data processing. Thus, the three kinds of value introduced above are all implicated.

But two other trends relating to data and interaction are worthy of note. The cloud accelerates the harvesting of personal data, to be sure. But it also enables other new data flows, through both the Internet of Things, and systems which support social computing. The Internet of Things (IoT) is "the set of technologies, systems and methodologies that underpins the emerging new wave of internet-enabled applications based on physical objects and the environment seamlessly integrating into the information network" (UK Internet of Things SIG Roadmap, March 2013). Social computing is where social behaviour meets computational systems. It encompasses current online social interaction, but also generates people-powered computation, with applications from online auctions to recommendation systems, from election monitoring to citizen science.

Mortier et al.'s concept of human data interaction is focussed on personal data, and the problems and needs associated with it. The IoT and social computing introduce at least two new options. Consider the IoT. First, we need to interact with data, and perhaps we can use things to help us do that. But secondly, we will sometimes need to interact with the things themselves, and we will therefore likely need to transform IoT data into forms with which we can interact. Thirdly, any new interaction with data or things can itself generate further data, given suitable instrumentation. Finally, it would be natural for levels of access to depend upon on the roles individual actors play with respect to collections of things. In these respects, social computing is analogous: people can use social computing systems to interact with data; they can use data to interact with the systems; their interactions generate further data; and what they can do will depend upon their role in the larger system.

Drawing these points together, we see that they are simply facets of a world of distributed computing in which the cloud helps separate the physical mechanisms of sensing, storing, processing, communicating and acting upon information. Some mechanisms are local, others remote. Some mechanisms are obviously computers, others look just like things, and yet others are people. This picture multiplies the numbers and types of agents at loose in the world, but it is obvious that all the data flows and information processing are still entirely supervenient on physical mechanisms. But some of the mechanisms are out of sight of the people involved in the data flows, and so it is quite understandable that they distinguish the material, visible things from the immaterial, and sometimes invisible data flows.

Some of the data which people interact with can be considered "research data", in the sense that it is collected to inform the design of products and services; at the same time, sometimes data (big or small) is itself a major part of a product or service. In the former case, the main people interacting with data are designers; in the latter case, it is end users who do most of the interacting (thanks to the designers). So data plays multiple roles in design research. Moreover, the problems of human data interaction identified by Mortier et al. are important, but they are not in fact specific to personal data; they apply also to the other data flows, including those involving IoT data, and social computing data. This being so, how can these problems be tackled by designers of future systems of people, things and computers?

4. A framework for designers

With an established history in the development of creative methods toward the gathering of empirical data, designers have made significant contributions to how quantitative and qualitative data support a more user-centred design of products and services. However the advent of mobile and ubiquitous computing presents the discipline with a more complex array of data forms that are mediated in different ways and as such, they demand that we think about how designers design around data. In looking for a means of distinguishing between the forms of data that designers are now faced with engaging with, the authors identified an increase in the performativity of data. From types of stable data that remain immutable, through data that is transformed with the networks that it is associated with, to data that is beginning to produce its own data, there is a continuum in which data begins to speak for itself (Cox 2014). Performativity is a complex term that Dewsbury describes as "the gap, the rupture, the spacing that unfolds the next moment allowing change to happen." (2000), and traditionally performativity is used to explain the capacity of speech and gestures to act and offer emergent structures. The term is attributed to the language philosopher Austin who established that words can be used not only to describe something, but can used to do something. His most poignant example of what he coined as 'performative utterances' being when we use the words "I do" to instantiate an action (such as marriage) (Austin 1962).

Acknowledging that data is starting to 'do' things, we turned to the ablative case in Latin that indicates an agent, instrument, or source within a relationship expressed by 'by', 'with', or 'from'. If designers are having to adapt to how they derive knowledge through data, the ablative case might best describe how the data that they are working with is increasing in its performative qualities. By reversing the traditional ablative case in which 'by' is given agency, 'with' is co-produced and 'from' is taken, it is possible to express the shift in practices that designers have begun to develop as data moves from being something like a source to design 'from', to a complex and fluid setting to design 'with', and finally to a condition in which design is produced 'by' data itself.

4.1 Design from data

Design **from** data: when systems are designed by people, where they are inspired by measurable features of humans, computers, things, and their contexts.

There are many methods that designers use to elicit data from social, technical and environmental settings: from established ethnographic methods from user observations (Abrams 2000, Stempfle 2002 and Kawulich 2005) and interviews (Bernard 2000, Byrne 2001, Rubin 2005); to more designerly methods including cultural probes (Gaver et al 1999), technology probes (Hutchinson 2002) and Contextualmapping (Stappers et al 2005).

Criticised by Norman if solely used at the beginning of a design process (2006), user and participant observations help designers gather data from people in specific situations. From 'fly on the wall' approaches to the use of video, still photograph and note taking, the gathering data from contexts in which people are carrying out everyday practices or using prototypes, is a familiar method for designers to understand social practices. Similarly, the use of structured, semi-structured and un-structured interviews also offers a valuable method to gather data about the perceptions, behaviour and opinions of people who are engaged in the consumption, use or interaction with particular products and contexts. Whilst participant observation and interviews are extended from established ethnographic methods, cultural probes and context mapping are more unique to design and use artefacts and materials to gather data. Packs consisting of various elements such as diaries, disposable cameras, postcards and drawing materials that are distributed to project participants, encourage them to describe their experiences without the presence of the design researcher. Use of graphics, metaphors and personalised touches can support participants to offer imaginative material to inspire the design process. In the development of technology probes, Hutchinson et al. acknowledge how "probes will change the behaviour of our users" (2002) and subsequently developed a probe that uses technology to foster a co-adaptive relationship with the user in which the device provokes and promotes interactions from which understandings of use and context can be elicited. Explicitly not a prototype, technology probes stimulate use over a period of time, and allow researchers to reflect on this use in order to gather information about the users as well as inspire ideas for new technologies. Contextmapping, also a design technique, uses a series of phases that begin with the capture of the designers' preconceptions for a setting, followed by the use of a variety of stimuli (including questions and cultural probes) to help participants reflect on a circumstance or situation. Sessions are usually recorded to support the identification of patterns in language, experience and practice.

The variety of methods for gathering data is not limited to the four examples above but extends to all processes in which data is gathered 'from' settings before being analysed and used to inform subsequent design decisions. Through the multi-disciplinary Equator project, a good deal was established about the appropriate ways that data can be gathered and used to inform design. Hemmings et al. list seven steps toward design: 1. Planning; 2. Recruiting Participants; 3. Selecting Volunteers; 4. Assembling Domestic Probes; 5. Deploying Domestic Probes; 6. Retrieving and Analysing Probes, before 7. Speculative Design (2002). This order of data capture ultimately ends in the studio, where the designer can learn and design 'from' the materials.

Figure 1 The Haggle-O-Tron was developed using a combination of design from data methods including video ethnography and participant observation through the use of a technology probe.

An example of how the authors have developed a Design From Data approach is in their development of the Haggle-O-Tron (Speed et al 2014). The Haggle-O-Tron is an interactive kettle that was developed for placement within an Oxfam secondhand shop to explore how haggling (a practice currently prohibited in Oxfam shops) might be helpful in revealing secondhand goods' financial, moral, social, and aesthetic properties. Visitors to the shop were invited to use the kettle to haggle over the price of an article that they were interested in buying. A member of the design team who was located in the shop's backroom and was connected to the Haggle-O-Tron via a web camera and microphone. This 'Wizard of Oz' technique allowed us to simulate the kettle's sentience, in order to sustain a realistic haggle. From reviewing footage and identifying interactions back in the studio, the researchers gained a better understanding of bargaining tactics, the use of incentives and the effective vocabulary that would support Oxfam's wider charitable projects, whilst offering them an insight into how they might change their in-store policies.

4.2 Design with data

Design **with** data: when systems are designed by people, where they take into account the flows of data through systems, and the need to sustain and enhance human values.

As the network society has developed, ethnography in turn has developed means of expanding its practices to utilise social media, telecommunications and internet communications in order to gather data. Virtual ethnography (Hine 2000), netnography (Kozinets 2006), cyber-ethnography (Keeley-Browne 2011) and online ethnography (Wilson 2002) all refer to online research methods that have adapted traditional ethnographic methods to study participants through computer-mediated social interactions. Whilst these methods largely gather material and report 'from' sources before analysis, easy access to ubiquitous computing technologies is enabling researchers to sustain a link 'with' a participant or community to better understand how data-centric prototypes, products and services have an impact on the user. We describe this emerging research scenario, in which information can flow in more than one direction, as one in which it is possible to 'design with data'.

The constant connection to the internet between products such a smart phones or services such as energy through smart meters in homes, is transforming the industry of design. No longer are designers simply contributing to stages in a value chain as a product moves from manufacture, packaging, distribution to consumption; designers are retained to mediate the value of products and services within a complex network of social and environmental connections. Coined by Normann and Ramirez (1994), the term 'value-constellations' describes the economic systems that emerged at the end of the 20th century as globalisation and new technologies influenced the way that value was sustained. Recognising the role of co-created value within networks, Normann and Ramirez highlight that "successful companies conceive of strategy as systematic social innovation: *the continuous design and redesign of complex business systems"* (1994). Within a value-constellation, the value of a service is constantly mediated according to the flows of data that allow users and stakeholders to sustain the value proposition associated with a product, service or experience. These more dynamic models of value creation and relation represent a different opportunity for design to retain a relationship with users throughout their engagement with products (Speed & Maxwell 2015). The opportunity for designers to 'design with data' that is derived from the interactions of users enables a different understanding of how the feedback from user communities affects the value of a product or service.

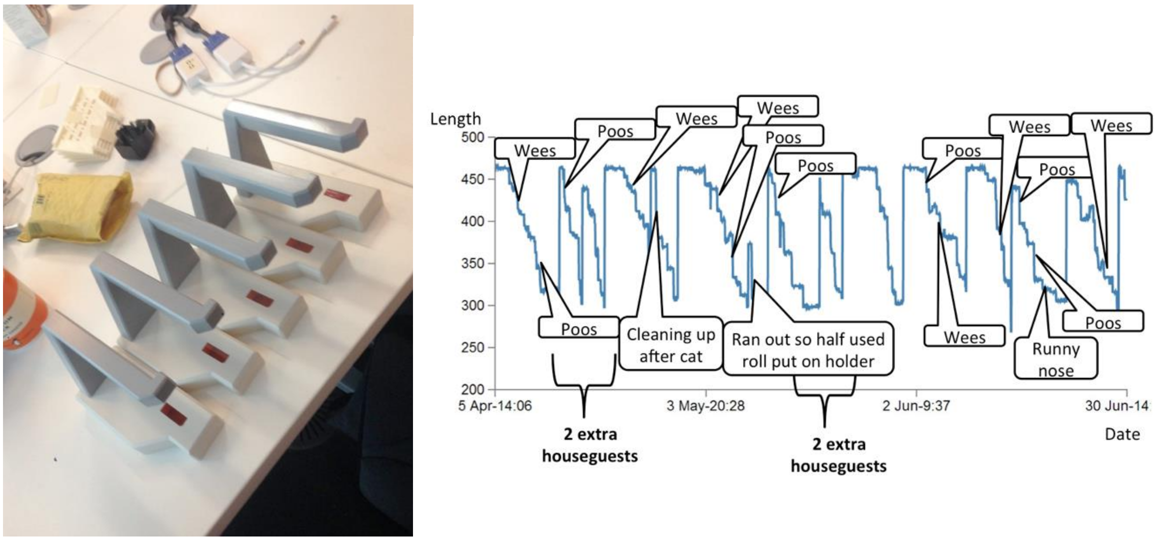

Figure 2 Five internet connected toilet roll holders waiting for deployment, and a screen capture of data streamed to the internet annotated with reflections from one owner.

An example of how the authors are involved in designing with data arises in the deployment of five internet connected toilet roll holders that fed back data to their owners. The design of the flow of data was relatively simple: each device concurrently measured the mass (and hence length) of remaining toilet paper, and streamed the values to a designated recipient.

The design solution was developed for an Internet of Things research project that provides a platform for owners of connected devices to lay claim to the data that they produce and begin to explore ways in which to trade with it. Current business models for IoT devices involve the customer purchasing a device that supports particular network functions, but often streams data back to the manufacturer who may sell the data to third parties, or use it to inform their own economic strategies. The Hub of All Things project (www.hubofallthings.com) seeks to provide a platform for people to manage the use of their own data and in turn identify value from it by either choosing to protect it, share it or potentially sell it.

Originally identified by the research team as a relatively easy Internet of Things device to design (compared to fridges and other domestic appliances), the toilet roll is at the centre of highly personal practices that take place behind locked doors and exemplifies the type of personal data that people may want to manage. Through the graph that is fed to a personal data store and visible in a browser, it is possible to clearly identify events that use significant amounts of toilet paper from which it is further possible to infer particular toilet activities; see Fig. 2. Upon further analysis, the graph also revealed a series of less likely events including cleaning up after cats, the running out of toilet paper, extra house guests, and somebody having a runny nose. The performative nature of the data emerges as families begin to interpret the data to infer domestic practices, and in one case identify the presence of a stranger in the house, whilst a family were away on holiday.

Designing with data acknowledges that data is not a cold resource to be taken back to the lab or studio for examination, but a condition in which designers should anticipate the disruptive potential that is produced from streams of live data from networked artefacts. Trust, privacy, identity and security are concepts that as humans, we determine the value of within complex social and material practices. In order for designers to understand the breaches and disruptions involved in the human data interactions between internet connected things, we will need to develop 'design with data' methods in order to understand the value constellations that are produced and co-produced to support better management.

4.3 Design by data

Design **by** data: when systems are designed by other systems, largely autonomously, where new products and services can be synthesised via the data-intensive analysis of existing combinations of humans, computers, things, and contexts.

The final area is in the emerging prospect that data itself, supported by an algorithm, will become a designer. Such a circumstance is not so far away, according to Gartner, who predict: "By 2017, a significant disruptive digital business will be launched that was conceived by a computer algorithm." (Gartner 2014)

The scale of data that is being produced and co-produced through machine to machine and machine to human / human to machine interactions has proven to be exponential. It has been observed that approximately 90% of all of the data in the world has been produced in the past 2 years (Arthur 2013); whether this is in fact true now, the exact proportion is perhaps irrelevant. As the flow of data moves from web based applications, through mobile devices to networked objects, the data that is produced becomes the primary asset with which to sustain the value of products and services. If the information that is derived from the data and returned to the user does not demonstrate good value, then the user may drop the product. In order to identify valuable information, machine learning is being used across a wide variety of databases to identify patterns in order to elicit new insights (Bandyopadhyay & Sen 2011). Design by data suggests that as these algorithms become faster and better at identifying new opportunities to sustain or add value to products and services, it won't be long before data-driven objects begin to become designers within our lives.

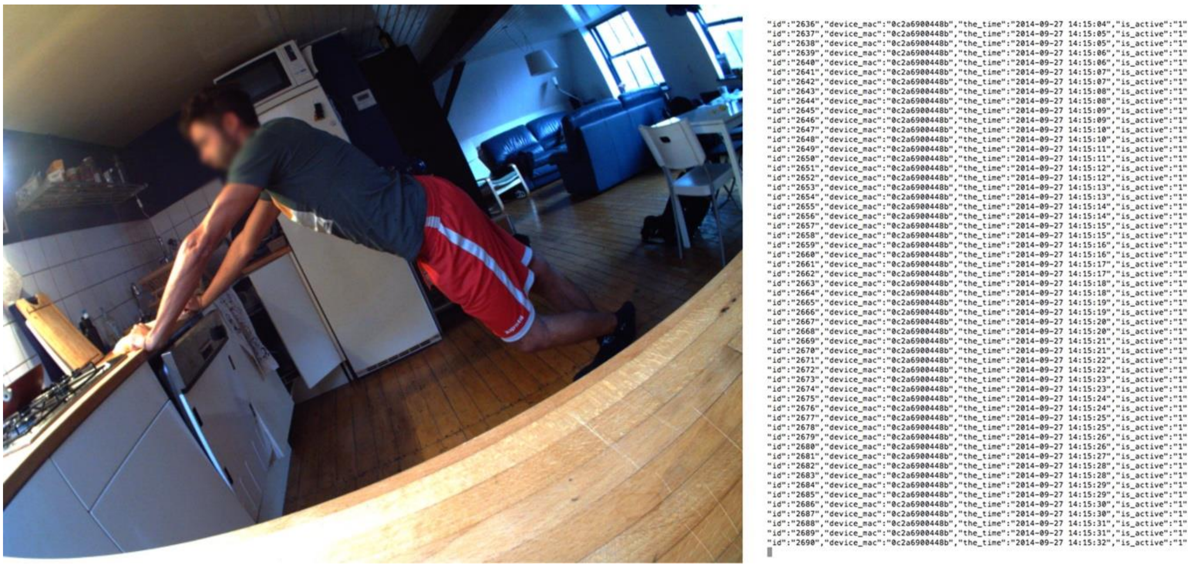

Figure 3 The ThingTank project adopts a design by data approach. Cameras attached to domestic objects allowed human researchers to identify activities, whilst data from internet connected devices allowed machines to learn about human activity. This combination enabled the researchers to identify more than human activities that were done while waiting for the water to boil (from a kettle's perspective).

The case study that the authors have contributed to that best exemplifies a scenario of 'design by data' is the ThingTank project. The project was funded to explore the potential for identifying novel patterns of use within data that is streamed through the interaction between people and things, and things and things. Through an understanding of what data can tell us about how we use objects in practice, the project posited that new models of use would emerge and reinvigorate the role of things and people within design and manufacturing. In the past, many Internet of Things projects have used the network connection of artefacts to identify cost saving and process efficiencies (e.g., vehicle manufacturers), or to track goods within large networks (e.g., logistics companies), or to monitor the health and safety of systems (e.g., aircraft manufacturers). Such projects look for regular patterns within datasets which suggest efficiencies that will reinforce the identity of a product or service by making its function easier to use or more economical. By contrast, the ThingTank project proposed that looking for anomalies and outliers in datasets could suggest more radical design opportunities. During studies, the research team developed non-anthropocentric methods by gathering and streaming data from both material objects and humans that were involved in a domestic relationship, to better understand how machines could identify practices that went unidentified by human researchers (Giaccardi et al 2016).

Although the majority of us use products as intended, many of us also invent novel usages of objects by adapting or using them for unintended purposes. By scanning large datasets for evidence of mis-use and then using them to build new assemblages, the ThingTank project proposes that algorithms may exploit data to design things that human designers could have never have conceived.

5. Reflections and Implications

Collectively, we term these three classes of designing from, with and by data as the "Ablative Framework" for design informatics, referencing the ablative grammatical case in Latin, which is used to cover "by, with or from". The flow of data, and the generation of differing forms of value, are the central concerns and allow designers to reconfigure existing practices and methods to better understand the increasing performativity of data. The framework sees design **from** data as established methods for designers, and design **by** data as still highly emergent; whilst design **with** data is the important space of enquiry that requires urgent research to address the full extent of Human Data Interactions.

The Framework aims to offer a means of organising both existing methods but also of anticipating emerging methods that recognise the increasing performative qualities of data. The Framework is placed within a network society in which designers are working alongside a wide range of disciplines to mediate value within a constellation of stakeholders including algorithms. The Framework identifies different relationships between designers and data, and helps us see when the use of established ethnographic and designerly methods for gathering data **from** is required, or when the sustained flows of data require a design **with** data. The ThingTank example in fact demonstrates this neatly: the designers pursued traditional design methods, and then constructed flows of data from devices embedded in users' practices and values, and then engaged machine learning to identify outliers, which points towards the increasing automation of new product design. So the project involved all three relations between design and data; the Framework does not instantiate a hierarchy for the three relations, and acknowledges the importance and interaction of all three within design research.

Uses of the three cases can be understood in terms of the need for some design projects that depart from the standard double diamond of design, with its pipeline of four stages: discover, define, develop and deliver. Such an approach typically identifies the behaviours and conventions that have to be observed, and finds ways of sustaining them. With the advent of designing alongside data, there is limited chance to freeze the discover and define stages, because data will continue to be received from users and communities that adjust the value proposition of the product or service that has been delivered.

Design is adjusting from providing services that add value along the traditional value chain, towards playing an active role in the mediation of value within a constellation in which data provides feedback, or even takes control. Frameworks such as the one proposed here provide tools which help us understand which methods to adopt, and when. Some of those tools should be very simple, taking the form of checklists for practitioners that respond to the following questions:

1. In contexts in which humans, computers and artefacts are in close interaction, how can designers identify measurable features from which data can be elicited to better understand the values in play, and how can they design interventions to capture data in a manner that is sensitive to human values?

2. In contexts in which data is flowing in such a way that it is performative, informing and affecting the behavior of humans and artefacts, how can the design team develop systems that capture the existing flows, and offer interventions that support and enhance human values?
3. In contexts in which systems are designed by other systems, how can designers mediate the development of products and services that are synthesised by data processes, to ensure that the values of the systems are commensurate with the values of the human and more than human participants?

In future work, we aim to exercise these principles and make them broadly available for design research.

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Feel it! See it! Hear it! Probing Tangible Interaction and Data Representational Modality

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Abstract: In this paper we present the design, implementation and evaluation of three tangible devices that measure and represent indoor air quality through different modalities. The motivation for creating these devices is twofold. First, we are interested in exploring how tangible interaction, combined with different representational modalities, affects the way people perceive data. At the same time, we aim to provide people with a novel interface that makes them aware of ambient indoor air quality. To achieve this, the approach we take is to create, what we term *design probes*: three objects that possess similar design features but differ in one aspect (here: representational modality). We discuss the design rationale and technical implementation of these devices and follow by describing a deployment study conducted to explore their use in real environments. Based on the results of this study we divide our discussion into three parts: *Social Aspects, Personal Space* and *Subtle Changes.* We conclude by presenting future research plans that aims to probe deeper into how representational modality affects people's experience of data.

Keywords: Tangible Interface; Representation Modality; Indoor Air Quality; User Experience;

1. Introduction

Until recently, the application area of data representation has predominately supported analytical tasks for expert users. Today, however, data representations are frequently used in more informal settings such as casual scenarios (Pousman, 2007), storytelling (Segel, 2010) or museum display (Hinrichs, 2008). Inspired by the transition of data representation into these environments, as well as resurgence in representing data beyond the visual modality (cf. Vande Moere, 2008), we present three portable data-driven devices that measure and represent real-time levels of indoor air quality (see Fig. 1). These devices provide people with a novel tool, which is designed to heighten people's awareness of indoor air quality (IAQ) and encourage them to take action, such as opening a window to ventilate the space and improve their working or living environment without impacting on the energy consumption of the building.

When seeking to maintain a healthy lifestyle and working environment, an aspect we often overlook is the quality of the air around us. It is a common misconception that the quality of indoor air is higher than that of outdoor air. In fact, recent studies have shown that indoor levels of pollutants are two to five times higher than outdoor levels (US EPA, 2009). One of the most important indicators of IAQ is the level of Carbon dioxide (CO_2) in the ambient environment.

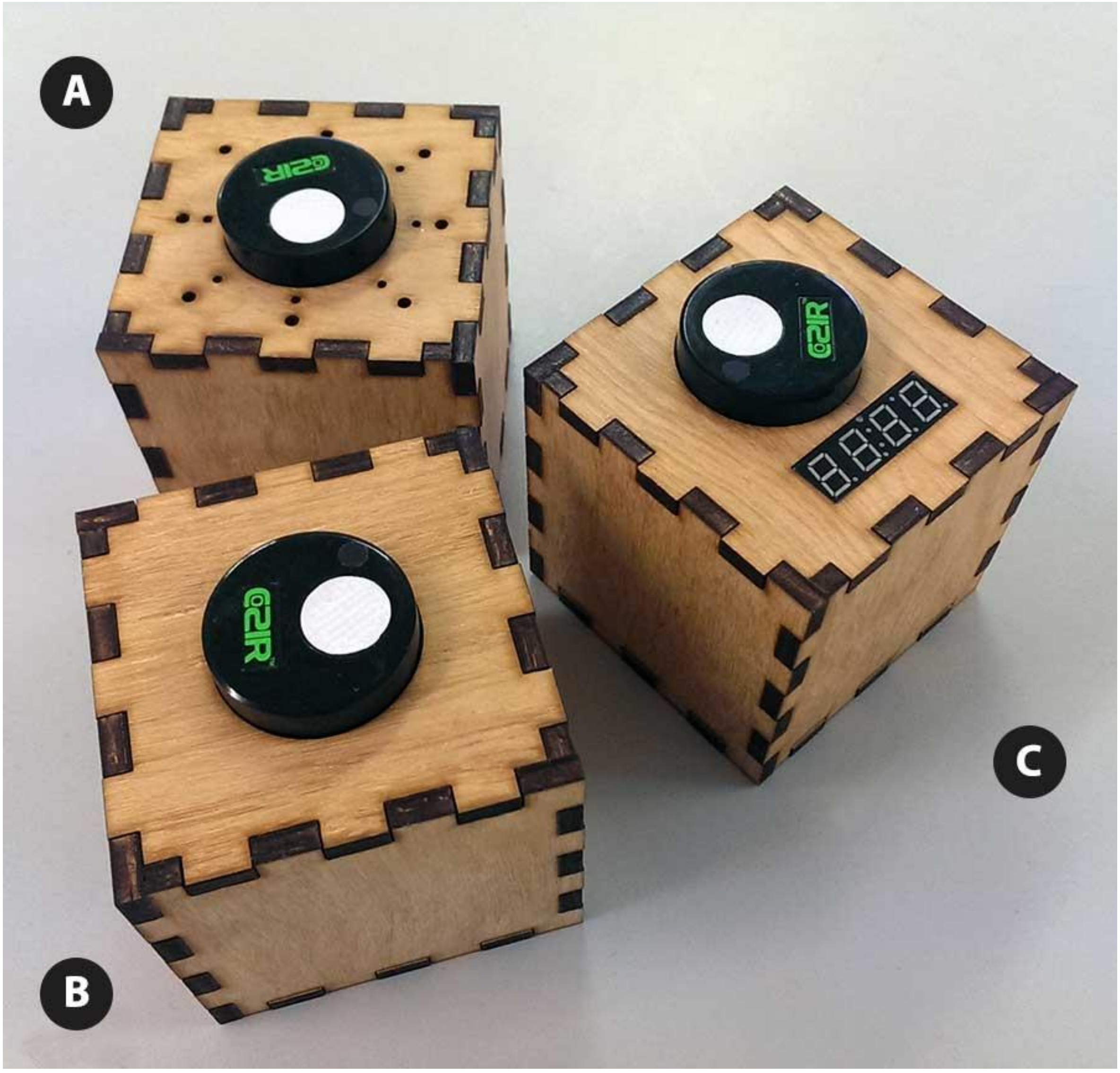

Figure 1. (A) Auditory Interface, (B) Haptic Interface, (C) Visual Interface

This work is part of our wider research agenda, which seeks to answer the question: *how does representational modality affect people's perception and experience of data?* The research we present here is the first part of a multi-phase project that seeks to answer this question. To this end, we designed three prototypes that are identical apart from the modality used to represent the data (auditory, visual and haptic). We then deployed these prototypes in real-world environments to study their use. We do not claim that this study fully compares the affect that different representational modalities have on people's experience of data. Instead we were more interested in collecting responses from people who have used the devices as part of their home or work life, to help shed light on different design aspects of the devices.

The contribution of this paper is not only confined to the design and implementation of these prototypes, we also present a discussion on their use, which is derived from deploying the devices in real-world environments for a period of three days. Based on the data collected during this study we highlight key design implications and discuss potential scenarios where tangible interaction can assist data representation and exploration.

The rest of the paper is structured as follows, we first describe research related to our work, and we then present the design and implementation of the devices. We follow this by describing the deployment study and we divide our discussion into three parts: Social Aspects, Personal Space and Subtle Changes. We then consider possible usage scenarios for the different representational modalities and conclude by presenting future research plans that aims to probe deeper into how representational modality affects people's experience of data.

2. Related Work

Research on representing data beyond the visual modality can be traced back to the late 1990's with developments in Calm Technology (Weiser, 1995), Ambient Media (Ishii, 1997) and Ambient Information Visualization (Skog, 2003). The challenge here was to place data representations in the environment of the user instead of a screen on the desktop computer. This focus still remains today (cf. Jansen, 2013), and developments, such as, easily accessible microcontrollers and rapid prototyping technology has further expanded the field and offered opportunities for design researchers to explore new ways of representing data.

The work we present here is a continuation of our previous research that investigates people's experience of data represented through different types and levels of modalities (cf. Hogan, 2013). We have already have shown that the modality and combinations of modalities used to represent data influence the user-experience and affect the way we interpret data (Hogan, 2012). However, the primary focus of these previous studies was to interrogate representational modality, and thus the data source, design and context of use were not prioritized. In the present study we seek to address this imbalance by designing a set of data-driven artefacts, for a genuine purpose, and specific context of use, while also exploring the individual characteristics of different representational modalities.

The topic of representing data beyond the visual modality and in particular encoding data in physical forms has received increased attention lately, see for example (Alexander, 2015) and (Stusak, 2015). Over the years, various attempts have been made to define and delineate this field of research, from Zhao and Vande Moere's definition of *Data Sculpture* (2008) over Vande Moere's concept of *Data Physicality* (2008) to the recent novel definition of *Physicalization* (Jansen, 2015). Recent work has also attempted to establish a framework for visualizations beyond the desktop paradigm, to help us describe, compare, and critique non-screen based data representations (cf. Jansen, 2013). Alongside these theoretical investigations, we continue to see examples of work that take a more practical approach to representing data through the tactile or haptic qualities of physical forms. Haptic Shoes (Fu, 2005), comprises of a pair of shoes that have been embedding with vibration motors to alert people about fluctuations in their financial stocks, while Laura Perovichis has translated indoor air quality data into decorative fabrics and clothing (Perovich, 2015). The Stock Orb (Ambient Devices, 2014), represents financial data through modalities other than the traditional form of alpha/numerical, here the data is mapped to the colour of a glowing orb. Please see (Jansen, 2015) for thorough survey of current state-of-the-art in physical data representations.

While research into representing data through physical forms or haptic feedback is relatively new, representing data through sound has a longer tradition. Known widely as *Sonification* (Kramer, 1997) or *Audification* (Hermann, 2004), research in this area dates back as far as the invention of the Geiger counter in 1908. Notably research in the area of Sonification includes Krygier's (1994) work on sound and geographic visualization. By considering the different qualities and characteristics of sound Krygier established a set of sound variables (location, loudness, pitch, register, timbre, duration, rate of change, order and attack/decay) that can be used in the representation of data through sound. More recently, research into targeting the auditory perception of humans to make sense out of data has tended to explore its use as assistive technology (cf. Lenay, 1997) or by combining it with other modalities (cf. Hoggan, 2007)

Although the primary focus of our research is on representational modality, the source of the data: indoor air quality (IAQ), has also attracted attention from researchers who have sought to investigate the affect air quality has on humans. However, historically, outdoor air quality (OAQ) has received greater attention. From a Design and HCI perspective, exploring IAQ was far more intriguing to us than OAQ, as to address OAQ it would possibly require a societal, cultural and economical shift in thinking, whereas encouraging and helping to facilitate a change in individual behaviours has a direct influence over the indoor breathing environment. Related work in this area includes (Jiang, 2011), who created and investigated the use of personalized mobile sensing systems for IAQ monitoring. Related to this is PiMiair.org, a participatory indoor air quality data sharing project that was launched in January 2014, where users can use mobile sensing units, placed in buildings across China, to access and share local IAQ data using Bluetooth connectivity and a Smartphone. Research has also been conducted to explore the IAQ within the context and environment of family homes (Kim, 2009), showing how conscious awareness of habitual behaviours with regard to

IAQ, can improve indoor environments, and finding that a simple visualization may be enough to initiate this change.

3. Design Process

To help achieve the goal of our research, the approach we use is what we term *Design Probes*. Although this approach is similar to *research through design*, it is unique in so much as it doesn't involve an iterative process, which is integral to *research through design.* An iterative process involves designing a series of artefacts *consecutively*, where improvements are made in new designs based on the design knowledge gained from studying previous versions. I also consider it to be close in intent to *Technology Probes* (Hutchinson, 2003), however, instead of studying the use of one artefact (which is the procedure followed with technology probes), I create design multiple artefacts that possess similar design features but differ in one aspect (e.g. representational modality). This allows researchers to focus the evaluation precisely on this design feature - in my case this was representational modality.

In the early stages of the design process we made a number of key decisions resulting in a design criteria for the prototypes. First, the devices should be portable so they can be moved within an environment and shared by people who occupy this space. Also, we did not want the devices to be autonomous; instead, they should require explicit user-interaction to request the data, unlike people's role with ambient or peripheral displays (Skog, 2003). We made this decision; as we were interested in focusing our investigation around the specific moment people perceive the data representation. Requiring people to interact with the device to display the representation allows us to focus on the specific moment during their experience of the device when people begin to interpret the data. Finally, we designed the physical shape of the devices to fit comfortably into an adult hand and also so that they could be placed safely on a flat surface. This shape also offered us multiple surfaces to be exploited for user interaction.

A fundamental element of all data representations is the type of modality used to represent data. In this case we selected auditory, haptic, and visual modality. In the auditory display, we map the data to the frequency (pitch) of a computer-generated sound, while the same data is represented through vibrations for the haptic display. In the early designs of the visual display we sought to use equally abstract representations, such as colour and position. However, in the prototype we present here, we us a numerical display, as we wanted to replicate the way IAQ is traditionally represented (numbers: PPM). The choice of wood as material for the cubes is influenced by the use of haptic feedback, since we found that natural materials conduct and evenly distribute vibrations better that synthetic materials, such as plastic.

One of the most critical design aspects was the style of user-interaction employed to trigger the device to measure and represent the IAQ. We envisaged the mode of user-interaction to be natural, familiar and intuitive. To assist the design of the interaction style we conducted an exploratory session to observe how people naturally interacted with handheld cubes. We invited 10 students to participate, asking them to interact and play with the cubes in order to elicit a response from within the cube. We fitted each of the cubes with a mini-speaker, which was controlled remotely by a researcher. On occasions, when a participant interacted with the device the researcher would remotely activate a sonic tone to be played through the speaker. This would signify to the user to try another form of interaction, such as shaking or knocking. This session lasted 30 minutes and during this time we recorded numerous ways people interacted with the cubes, which included, shaking, knocking, spinning, flipping, dropping and sliding the cube onto a surface.

3.1 Implementation

Next, three prototypes were created that require the user to shake them to request the real-time IAQ levels in the surrounding air. We implemented this gesture not only because it is natural and familiar, but we also found that it allowed the sensor to sample air from a larger area. The actuators used to display the data are unique in each of the three devices (see Fig. 2). In the visual interface (Fig. 1C) we incorporated a 4-digit, 7-segment display to represent the value in raw numerical format. In the haptic display (Fig. 1B) we used eight 5-volt vibration motors fixed to the inside walls of the cube. Once triggered, the speed of the motors is mapped to the IAQ data e.g. 400PPM causes very weak vibration, while 1500PPM causes strong vibration and so on. For the auditory display (Fig. 1A) we used a 50mm (diameter), 0.5W, 8-ohm speaker that generated sounds to represent the CO_2 values. The frequencies of the sounds played through this speaker are mapped to the value from the sensor; low value causes low frequency sounds and visa versa.

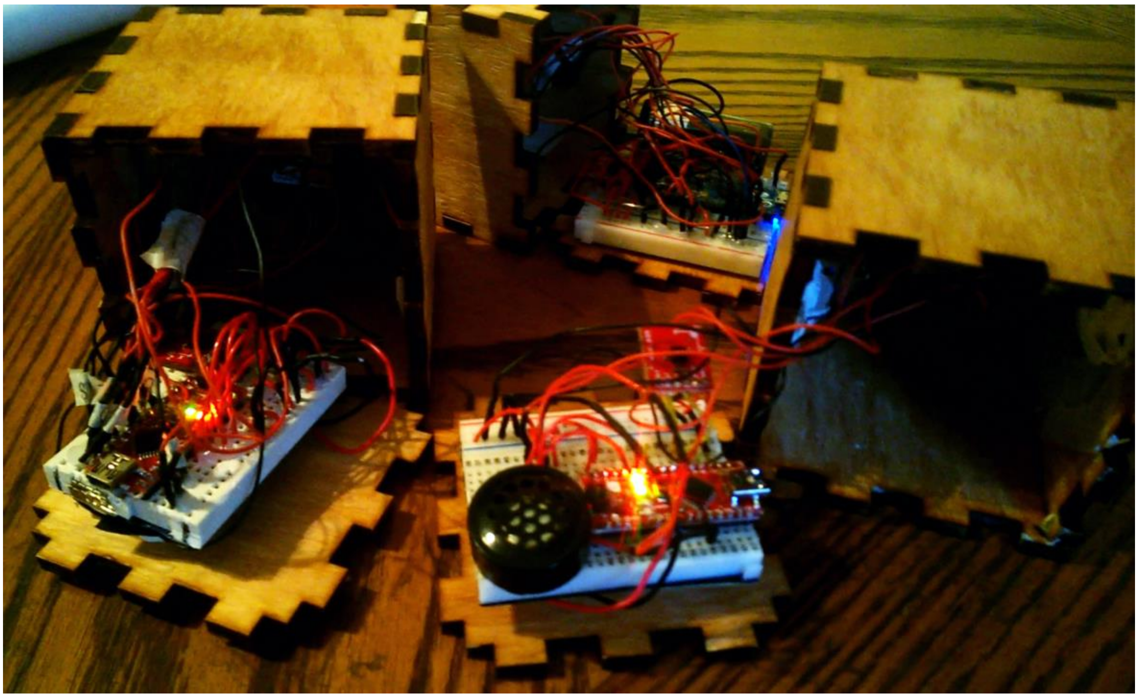

Figure 2. The working components of the design probes

Following a series of informal tests in our design lab, we observed a flaw in the system. Although people had little difficulty triggering the sensor, the majority spoke about their difficulty in understanding the value of the representation. To address this issue we incorporated a legend into each prototype, to allow the user to map the current levels against two pre-defined levels of CO_2. Each device now represents three values: the ambient CO_2 levels as well as fresh air values and unsafe levels of CO_2. To trigger the predefined values the user knocks on the sides of the cube, one side for fresh air and the adjacent side for unsafe CO_2. To capture the shaking gesture I used a triple-axis accelerometer, while for the knocking gesture, we fixed two 5cm circular piezo elements to inside faces of the cube. The real-time CO2 levels are captured using a COZIR™ ambient sensor, which measures the CO2 levels in the form of parts per million (PPM) and is suitable for battery powered applications and has a short warm-up period (1.2 seconds); other CO2 sensors that I tested either consumed too much power or had long warm-up periods (> 5-seconds).

4. The Study

To interrogate the design and better understand the use of the three design probes in different situations, we conducted a deployment study in the context of real living and working environments. We contacted a number of companies and people from within our social and professional circle to participate. When deploying the probes, we purposefully chose different types of locations to provide us with a broad spectrum of use and conditions.

The auditory device was deployed in a shared open-plan office that was occupied by 15 customer service professionals. The haptic device was placed in a small company office that has four fulltime employees occupying 3 private rooms, a shared meeting room and a public reception. The visual device was deployed in a 4-bedroomed family home, lived in by two adults (one working fulltime) two girls (5 and 7 years old) and a boy (9 years old). None of these locations were fitted with air-conditioning, however, the open-plan office had a motorised ventilation system embedded into some of the windows. Each probe was deployed in the same location for a period of three days. In each location we chose one person who agreed to take care of the device, observe its use, and would be willing to be interviewed before and after the study. These people included: Tom (39) solicitor (haptic device), Mary (34) stay-at-home mother (visual device) and Michael (25) customer service representative (auditory device).

Figure 2. The CO_2 cubes deployed in a domestic home (left) an open plan office (middle) and a personal office (right)

During a pre-study workshop, we introduced the devices and to our points-of-contacts and we asked that they pass this information on to others that may wish to use them. As part of the study we conducted two semi-structured interviews with Tom, Mary and Michael. The purpose of the initial interview was to assess their general knowledge and understanding of IAQ, while the post-study interview gathered information about: (1) how the devices were used, (2) general response to using the device, and (3) the participant's knowledge and awareness of IAQ. Based on the analysis of these interviews, the following sections provide a summary of key observations and findings.

4.1 Observations

Prior to using the devices, all the participants demonstrated a basic understanding of indoor air quality, but this was mainly on hazardous pollutants such as Carbon Monoxide. During pre-study interviews, many participants referred to CO_2 as being a key factor for global environmental issues but found it difficult to connect outdoor air pollution to the quality of air inside, one remarked

> "Carbon dioxide doesn't really harm us, don't we breathe it out all the time?... Surely it can't do me any harm if it came from me in the first place". (Michael)

In the follow-up interviews (conducted after they had used the device) we noted an increased awareness of IAQ. Although this was to be expected and may be due to the Hawthorne effect (McCambridge, 2013), we note that the participants seemed to be not only aware of the quality of the air but also on the implications of poor air quality on their health and well being. For example Tom (small office) spoke about using the devices more in the afternoon than in the morning, especially when he felt fatigued:

> "In the morning I hardly noticed the cube, it was there but it didn't grab my attention, but when I was getting a bit tired or if I felt a headache coming on I would reach for the cube and give it a shake...this was like me looking for a reason as to why I felt the way I did"

Each of the participants also spoke positively about being able to move the device from one location to another. For example, Mary (family home) spoke about the areas of her house that seem to be most problematic, these included the cooking and living area. She remarked that these areas were affected by the people's activities within the space and not by other factors outside of their control:

> "I can see the numbers getting bigger when I do things like cooking and cleaning, they are also really high when we relax together in the evening, it was us that was causing the problem...this is kind of relieving to know as we can then fix it".

We note that as well as taking advantage of the devices portability, she used the device to compare how different household tasks impacted IAQ.

We also note how the device was used in shared locations, for instance, Tom spoke about noticing an increase in the levels when he was in a meeting with others in his office:

> "At times during the meeting I would give it a quick shake to see how we were doing, this was sometimes followed by me opening the door or window".

He further explained how the devices stimulated a lengthy debate about the affects of IAQ, which involved numerous people attending the meeting measuring the IAQ in their own personal space.

We also found interesting responses to the use of representation modality. The haptic modality seemed to elicit a more visceral response than the other modalities. The participant who used this device spoke about feedback being like a "*bolt*" or "*jolt*" that would sometimes surprise him and would immediately grab his attention. While the audio modality seemed to have less impact, however, the participant did remark about how the high values caused a piercing sound that would alert him in the same way an alarm would. The participant who used the visual interface seemed to be most confused about the representation. She understood that low numbers (<600) signalled a somewhat comfortable environment but she was unsure why she was not feeling the effects as the numbers increased. She also spoke about the numbers being meaningless on occasions:

> "If it goes up or down by 5 or 10 I just don't feel it, why would it tell me if it has no affect on me"?

With the other modalities, the participants did not notice such minor changes in the representations. During the interviews all the participants explicitly spoke about the aspect of sharing the experience with others and the devices triggering conversations and debate in the workplace or at home. In the family home, the device was used, on occasion, as a tool to teach the children about household responsibilities, while the office workers explained that the devices prompted debate between colleagues about the impact that poor ventilation and air quality may have on their working environment.

4.2 Design Implications

When we examined the data gathered during the study we found that all participants spoke about their ease-of-use and their increased awareness of IAQ, which was not a concern for them beforehand. However, the study also highlighted specific design issues as well as more profound questions that warrant further investigation.

Before addressing issues of user experience let us briefly acknowledge usability concerns raised during the study. On more than one occasion participants spoke about their difficulty in remembering which side of the cube related to fresh air and poor IAQ. They felt that having to constantly check each side impacted on their use of the device. The participants also described it being difficult to recognise subtle changes with vibration, however, the participant spoke more positively about this modality as it offered him two ways of interpreting the data (hearing and feeling). Work is ongoing to address these issues, which include creating tactile/visual labels for the sides of the cubes and we are testing other types of haptic feedback, which includes mapping the data to the frequency of knocks emitted from the device.

Moving beyond usability, we discuss three aspects of the design that emerged from analysing peoples of experience of the devices. We divide this discussion into three parts: *Social Aspects, Personal Space* and *Subtle Changes*.

4.2.1 Social Aspects

Following the analysis of the study there seems to be evidence to show that using tangibles to monitor and represent data stimulates increased debate about the data source. We provided our participants with a device that can be shared between a group and it would seem that this mediated and focused the conversation around the data. We believe that portability is not the only factor here, the size of the devices has also allowed them to be handed over and moved easily. Hornecker and Buur (2006) present a framework that supports social interaction through the design of tangible user-interfaces. Supporting the social aspects of data representation is especially important today, as their purpose has moved beyond just assisting domain experts with analytical tasks, but are now frequently used in casual contexts such as museums, libraries or at home. We believe that tangible interaction combined with data representation can play an important role in future developments of tools for data exploration in casual contexts.

4.2.2 Personal Space

The devices that we present here are different from how ambient data is normally monitored and represented. Typically, wall mounted sensors and displays are used to sample and represent data from a fixed point. The use of a portable device allows people to sample and represent the air space around them. We found that this creates a sense for the user that the readings are personal to them. To exemplify this, in our follow-up interview with Tom he referred, on a number of occasions, to the air as being *his* air, for example:

> "When I arrived back to my desk after lunch I noticed that *my* air had improved and was nearly as good as the air outside"

> "I was talking to Mark (work colleague) in the afternoon and we started to compare *each others* air, his seemed to be better than *mine* but that is cause his office is next to the exit but mine is in the middle of the building"

We believe this may impact on how the user is affected by the data, which may in-turn cause them to act more quickly in a given situation, such as opening a window when the IAQ drops.

4.2.3 Subtle Changes

During our study the participants who used the auditory and haptic display spoke about their difficulty in recognising subtle changes in the output, whereas small changes were immediately noticed in the visual interface. While some confusion was caused by the participant being able to notice minor changes but not understanding the implications, we believe that this reveals a characteristic of the auditory and haptic modalities that warrants further investigation. We believe these modalities may be better suited to representing non-critical ambient data, such as IAQ, where minor changes have no great impact. The visual modality may be more appropriate for representing critical data, such as carbon monoxide, where even small changes can be dangerous and life threatening. However, we acknowledge that the haptic and auditory devices in our study utilized analogue displays whereas the visual modality used a discrete representation (numbers). Further studies are planned which will use analogue displays for all devices, e.g. colour for the visual mode.

4.3 Limitations

We acknowledge that the study we conducted was short and only included a small sample of participants. A more complex study design might deploy all three devices in each location to compare participants' experience with each device. Also, we have conceded already that the discrete display used for the visual modality may have skewed the findings in relation to recognising subtle changes. Although this may be the case, we still believe that some evidence emerged which indicates that the haptic and auditory modalities are more suited to non-critical data representation.

5. Conclusion and Future Work

In this paper we have introduced and described the design, technical implementation and evaluation of three data-driven design probes that measure and represent real-time ambient indoor air quality levels through different modalities. Each of these probes has similar design features but differ in their use of representational modality (auditory, visual and haptic). They offer people a tool to be more aware of the quality of the air that they breathe in their work or home life. Over the course of three days, we deployed the devices to investigate their use in real environments, while also exploring how people experience different representational modalities. We learnt that the devices are intuitive, as participants had no difficulties operating them and in some cases they were appropriated for situations that we had not envisaged.

We also found that the devices stimulated and fostered social engagement around the topic of the data source. In relation to the different representation modalities used by the devices, this study seems to back-up previous work (Hogan, 2012), which shows that people's response, experience and perception of data is affected by different representational modalities. We also presented evidence that points to possible scenarios of use for auditory and haptic modalities, however, this needs further scrutiny. We are presently designing a study that will investigate this claim further. Alongside this, we are re-designing features of the devices and planning other studies to probe deeper into people's experience when using the devices, while also exploring whether this experience is altered by the use of different representation modalities. These will be longitudinal studies and will gather both qualitative and quantitative data to help us measure the behavioural changes of users and whether these changes have an impact on the indoor air quality of the spaces that they occupy.

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Designing Information Feedback within Hybrid Physical/Digital Interactions

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Abstract: Whilst digital and physical interactions were once treated as separate design challenges, there is a growing need for them to be considered together to allow the creation of hybrid digital/physical experiences. For example, digital games can now include physical objects (with digital properties) or digital objects (with physical properties), both of which may be used to provide input, output, or in-game information in various combinations. In this paper we consider how users perceive and understand interactions that include physical/digital objects through the design of a novel game which allows us to consider: i) the character of the space/spaces in which we interact; ii) how users perceive their operation; and iii) how we can design such objects to extend the bandwidth of information we provide to the user/player. The prototype is used as the focus of a participatory design workshop in which players experimented with, and discussed physical ways of representing the virtual in-game information. The results have been used to provide a framing for designers approaching information feedback in this domain, and highlight the requirement for further design research.

Keywords: Interaction, Feedback, Information Bandwidth, Prototyping

1. Introduction

Until relatively recently, most people would consider a video game as being confined to the virtual area represented on the screen, as this is predominantly the point of focus for players of the game. However, technologies such as the Microsoft Kinect, Nintendo Wiimote, and PlayStation Move have effectively made the space in front of the screen a significant part of the overall game experience particularly for co-located multiplayer games (Juul 2012). Whilst co-located players have previously used this space during play it has been principally been within the context of 'Trash Talking' (Voida, Carpendale, and Greenberg 2010) between players, in a similar vein to that seen in on-line games (Wright, Boria, and Breidenbach

2002), and players' focus is still primarily on the screen. However, as the Kinect, Wiimote, and Move are all designed to encourage greater physicality in the way the player interacts with the game this physicality turns the interaction into a performative act as was initially seen in the arcade game Dance Dance Revolution (Behrenshausen 2007).

In recent years we have seen the emergence of physical game objects such as Activision Skylanders, Disney Infinity, and, more recently, the Nintendo Amiibo which places the physical game objects at the centre of the activity by using them to control the characters and activities within a digital game running on a console (Coulton 2012) or tablet.

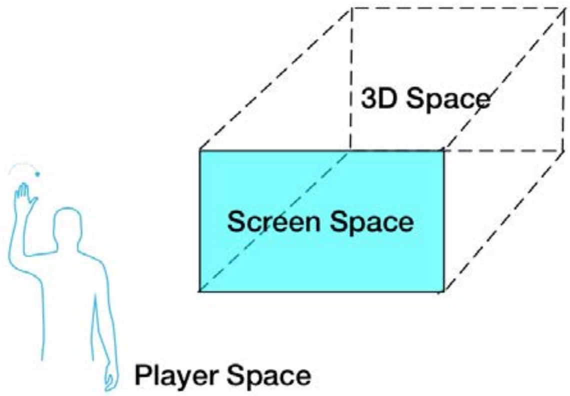

Figure 1. Game spaces as characterised by Jesper Juul in Casual Revolution.

One of the unique aspects of the Skylanders game objects is that a character type, name and abilities are stored on the physical game piece along with the players accrued experience of playing the game rather than on the console (Coulton 2012). While Skylanders, Disney Infinity, and Amiibo are arguably the most notable examples of game objects, there are also a number of 'app toys' appearing such as LEGO's Life of George, Disney's App Mates and the YetYet from Totoya Creatures. This focus on the object produces a number of very interesting effects such as: blurring the boundary between toys and games; expanding existing modes of game play to the physical world; providing the opportunity for physical play outside the game (Coulton, Burnett, Gradinar, Gullick, and Murphy 2014). Thus while these objects have a control element, they have value beyond being simply a game controller. Although some of these physical game objects provide some feedback to the player within the physical space, it is very limited, which leads us on to our main research question: 'How do we best feedback information to the player in both the physical and virtual spaces of the game?'

In order to answer this question we must first consider the space in which the interaction takes place, which is the subject of the following section.

2. Game Spaces

In considering the role of space when playing games, it was Jesper Juul in his book 'The Casual Revolution' (Juul 2012) that provided arguably the most useful framing when he divided game space into: player space; screen space; and 3D space as shown in Figure 1. Juul's aim with this framing was to highlight that in many casual games, such as those using Wii Sports, the player space has a much more significant role than in many of the more traditional console games (Juul 2012). This division of space allows us to address how physical/digital game objects can be designed to act in various ways, thus allowing designers to consider: where and how the interaction takes place; and where and how feedback on that interaction should be presented to the player.

In Figure 2 we highlight four possible interaction scenarios and, unlike the casual games explored by Juul, the question whether the games are either single or multiplayer does not dominate the discussion, as it is anticipated that all scenarios could support both single or multiple players.

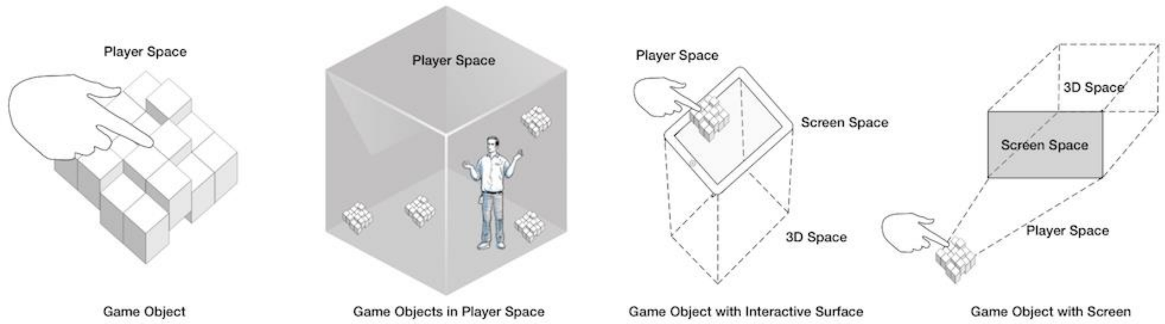

Figure 2. Potential Hybrid Physical/Digital Games Spaces.

- *Game Object:* In this scenario the game is the focus of the user's interaction and all the affordances that would be associated with the object. It is worth noting that as the object may exist both physically and virtually the affordances need to be considered in this context.
- *Game Objects in Player Space:* In this scenario we expect multiple game objects to be used to enhance the physical space. Whilst a screen might form part of this scenario, the game objects would not operate with it directly.
- *Game Object with Interactive Surface:* In this scenario the interactive surface provides both a screen and a means through which the physical objects interact with a virtual game which could be represented as either 2D or 3D space (Burnett, Coulton, and Lewis 2012).
- *Game Object with Screen:* In this scenario movements of the physical object are transferred to the screen via a wired/wireless link and, as with the previous case, the virtual game can be represented as either 2D or 3D space (Coulton et.al 2014).

It is important to note that these scenarios are representative of just some of the current possible game implementations involving objects and they should not be considered the only possibilities as designers may be free to configure the interaction within spaces as part of the overall game design. Further these scenarios are applicable beyond game and can be used to represent many forms of hybrid physical/digital interactions with connected devices.

Having highlighted possible scenarios we can now consider how information relating to the game can be provided to the player in such a space.

3. Information Bandwidth

Games often manipulate how much of information is presented to a player to create the overall game play. Salen and Zimmermann describe it thus:

> "When you create information in your game, its value for the player emerges from both its objective and perceived status: its structural position within a larger information economy and the players knowledge about that economy" (Salen and Zimmerman 2004).

In other words, information can be used as a primary game mechanic. In this research we are primarily concerned with how such information is represented to the user, i.e providing feedback associated with either players' interactions or events occurring within the game as this is generalisable to interactions beyond games. The focus here is to investigate in what way information can be made available to users, and what scenarios are best suited to which techniques.

We can consider the combination of channels that a system uses to communicate between player and system as the 'Information Bandwidth' of that system (Gullick, Coulton, and Lau 2015). For example, if the player's focus is only on the screen we are primarily using the visual and audio channels. However, if we are playing Wii Tennis, we are using visual, audio, and touch (through vibration) channels to convey game information. This concept of bandwidth is based partially upon the work of the physicist Tor Norretranders who characterised each sense by its data rate, in bits per second (bps), and differentiates between the amount of data we physically sense compared to the amount we consciously perceive (Nørretranders 1991).

Whilst it is possible to use only one channel to convey information, we believe that multiple channels are beneficial in a number of ways, of which two of the most important are:

- To avoid what we term 'Channel Saturation' - by conveying too much information to the user in one channel potentially overloading the amount of information the player can consciously perceive. For example while Nørretranders estimates we process visual data at 10 Mbps (Mega bits per second), but we are only able to consciously perceive 40 bps. Thus complex visual interfaces that change rapidly may cause the user to 'miss' information.
- When discussing Ambient Media [9], Ishii differentiates between media in the 'Foreground' (centre) or 'Background' (periphery). By combining foreground

and background channels we allow more utilisation of a player's attention. Norstranders' division of sensed and perceived information supports this idea.

This consideration of attention is also analogous to what Marshall McLuhan categorised as 'hot' and 'cool' in relation to media, whereby a hot media, such as print, is one that dominates one particular sense, absorbing our attention and leaving little room for participation, while a cool media (sometimes described as fuzzy) is one that engages across our senses and leaves space for participation (McLuhan and Fiore 1967). This suggests that when a player needs to act quickly within a game setting the feedback of information should be primarily provided through fewer channels than for slower, more explorative games that may need to give the player time for reflection. Arguably this feedback should additionally be provided through channels that can accommodate information with the needed immediacy for example: visual for immediate 'hot' or 'foreground' information and audio and touch for 'cool' or 'background' information. Given the emergence of physical/digital games there appears an opportunity of providing information in a greater number of ways relating the feedback to physical objects. It is important to note that we are not suggesting that these senses be divided into two discrete categories of foreground or background, but instead they should be considered as existing on a spectrum from entirely foreground to entirely background, and it can in fact be a mixture of both. A sense can exist on multiple points on this spectrum: sound can be foreground (a loud distinct beep for example), or background (a softly building ambient sound).

As an example of expanding the Information Bandwidth consider Table 1, which provides a limited selection of possible ways of representing different in-game information to the player.

Table 1 Alternative Representations of In-Game information

Information	Representation	Main Sensory Channel
Character Position	Projected Image	Visual (foreground)
Character Health	Heat/Cold	Touch (background)
Game Progress	Inflation/Expansion	Touch (background)
Game Event	Audio	Audio (foreground)
Weather	Mist/Vapour + Heat/Cold	Touch (background)

4. Expanding the Information Bandwidth

In order to help evaluate the effects of expanding the interaction using physical/digital objects, we designed and implemented a two-player tabletop game, known as Antus, focused around players controlling two rival ant colonies. In essence, Antus is a 'God Game', in that the player controls the game on a large scale, as if they are an entity with divine/supernatural powers. In this particular case each player takes control of an ant colony and must control the activities of that colony in order to survive. Integral to colony survival is keeping the queen ant happy with the winner being the controller of the ant colony that survives the longest.

The game contains both physical and digital elements as shown in Figure 3 and thus can be considered as a form of augmented tabletop game. This game has been designed in such a way that it has both information that could be characterised as 'hot' and considered to be available in the players 'foreground' of attention and information that could be characterised as 'cool' and suited to display in the users' periphery. Our aim was to use this game as a design stimulus for a workshop focused on presenting the information in the game space in a physical way.

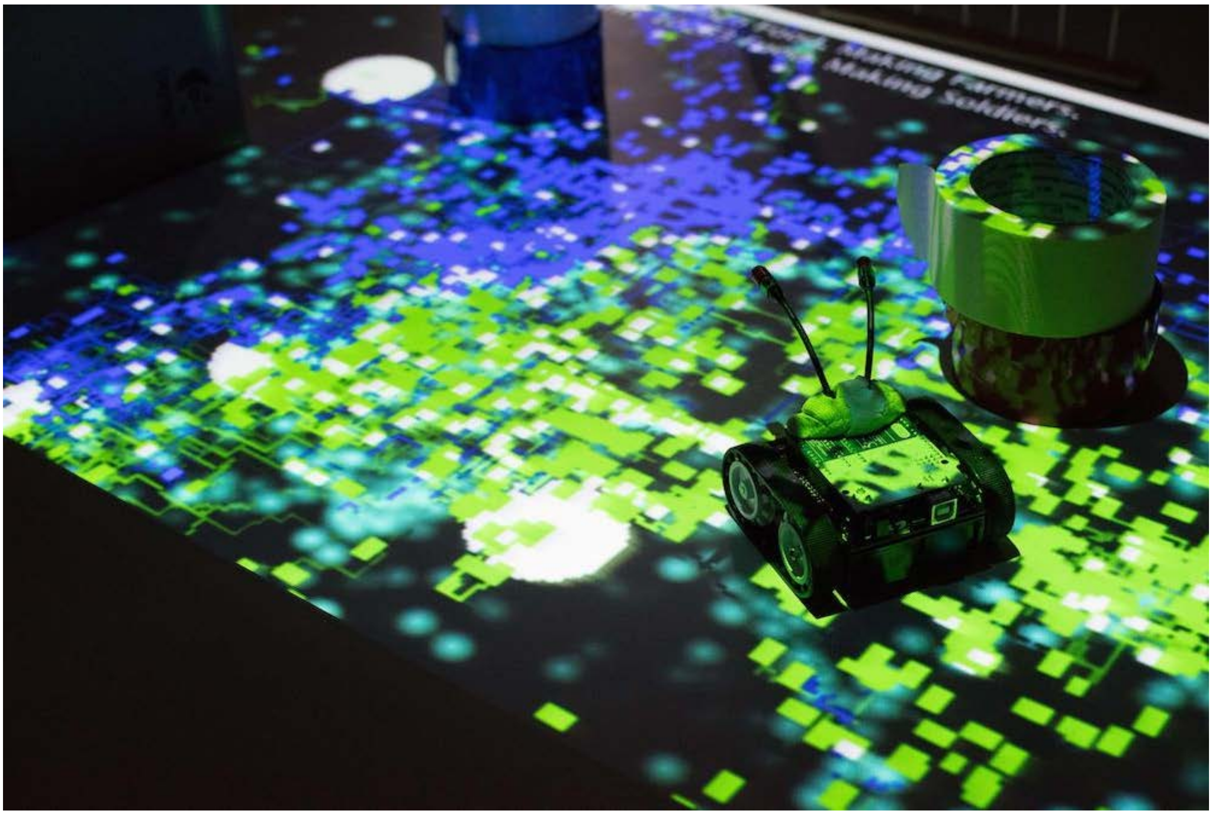

Figure 3. Antus Game (Robot Queen in Foreground).

Augmented tabletop games have been the subject of much research (Kojima, Sugimoto, Nakamura, Tomita, Inami, and Hideaki 2006, Leitner, Haller, Yun, Woo, Sugimoto, Inami, Cheok, and Been-Lin 2009 , Magerkurth, Memisoglu, Engelke, and Streitz, N. 2004) although the majority have largely been used to highlight novel technological interactions and they have not considered the information the object may be required to represent. While Baker et al. identified that players generally preferred physical objects over virtual ones (Bakker, Vorstenbosch, van den Hoven, Hollemans, and Bergman 2007) the issue highlighted by Magerkurth et al. of understanding whether feedback should be physical or digital within the context of augmented tabletop games (Magerkurth et al. 2004) or whether players prefer digital or physical representation remains unanswered. Additionally, there exists very little in the way of guidelines to help in designing physical feedback in games for different types of information, especially when focusing on the immediacy, and overall nature of the data represented.

5. Hybrid Physical/Digital Game Design

The game is situated on a tabletop scenario and uses a ceiling mounted projector that allows the system to augment the game space with visual information, and a ceiling mounted colour/depth camera allows the system to process the state of the game space system using image processing techniques. Figure 4 shows the system configuration, which provides a game space which conforms with the third scenario discussed in Figure 2 (game object with interactive surface).

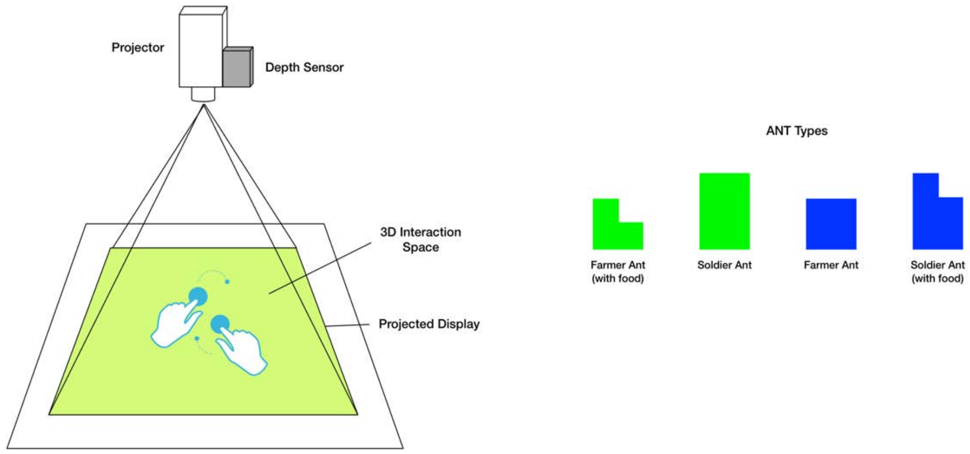

Figure 4. Hybrid Physical/Digital Game System and Ant Types

Initially, players are positioned at either side of the table and given control of a virtual ant nest (differentiated by colour) that is projected onto the table. Whilst a number of parameters that affect the colony can be controlled by the user and the main goal of this ant colony is to collect the 'food' resource and use it to produce more ants.

Using similar depth sensing techniques as 'Zune Buggies' (Wilson 2007), Illuminating Clay (Piper, Ratti, and Ishii 2002) and 'Efecto Mariposa' (Vivo 2011), the system can detect the changes within the terrain of the game space and react in such a way that the virtual elements in the game space react as they would if they were physical, much like in IncreTable (Leitner 2009). This means that players can place objects on to the table that result in the virtual ants treating the objects as obstacles and thus they seek to find an alternative route around the obstacle. In addition to detecting the shape of the terrain, the system can detect the presence and location of predefined physical objects, which can then be used as a tools using Holmquist et al's classification (Holmquist, Redström, and Ljungstrand 1999). In this case we detect the objects using fiducial markers (as used in camera based augmented reality systems) attached to objects, and detected via the overhead camera. Although other object tracking techniques are possible we felt that this is the easiest to explain and implement for the purposes of the participatory design workshop considered in a later section.

5.1 Game Avatars (Ants)

The are three types of ant present within the Antus game which are characterised by the following behaviours:

- T*he Farmer Ant:* This ant requires the smallest amount of food to be newly created within the colony. The farmer ant can collect food from a food source situated on the tabletop and take it back to their nest. On its way back to the nest the ant leaves a virtual pheromone trail to help other members of its colony find the food. This ant has no physical presence within the game space but will respond to physical changes (obstacles and food blocks) and other player interactions in the game space.
- *The Soldier Ant:* A new soldier ant requires more food to be created within the colony than a farmer ant. Whilst it cannot directly carry food back to the nest from a food source, it can attack ants from the rival colony and carry them back to the nest as food. Like the 'Farmer Ant', the 'Soldier Ant' has no physical presence within the game space but does respond to physical changes in the space.
- *The Queen Ant:* There is only one queen ant per colony and she sits on the users nest and uses food to create new ants. This ant has a physical presence in the form of a robot that is capable of moving around the tabletop game space. The queen ant will remain static as long as the colony is keeping her supplied with food but will grow agitated and eventually move to a new location if not supplied with sufficient food by the colony. The green queen ant can be seen in the right of Figure 3.

As discussed, the soldier and farmer ants are represented virtually within the game and in the current prototype as the simple abstract shapes, shown in Figures 4 and 3, in order to reduce the computational overhead when generating lots of ants within the game.

The virtual ants navigate around the game using the pheromone trails. Ants that have found food leave a 'food' pheromone trail on their way back to the nest, and ants leaving the nest in search of food leave a 'home' pheromone trail. Ants looking for home or food can then follow a trail of the desired type to navigate their way around the game space. These trails can be seen by the players and used to anticipate the reaction of an ant to a specific game scenario.

All three types of ant require food to survive and if left unfed will perish. Normally if an ant is successful in finding food it can restock its reserves and carry any surplus back to the nest in order to keep the queen ant happy, and to help fund any future ants being created.

5.2 Interacting with Game

The following colony parameters can be manipulated by the player by the positioning of designated objects in the game space:

- Stop (to stockpile food) or Start (at the cost of food) producing ants.
- Prioritise the creation of farmer or soldier ants.

Additionally the users can manipulate the game space by:

- Placing physical food blocks onto the table, which the ants can use as a food source (the game imposes a rule where the block has to be a certain distance from the nest).
- Physically manipulating the game space by placing objects as barriers. Ants are programmed to be lazy: they prefer not to go up or down hills preferring to find a route around.

6. Participatory Design Workshop of Physical Feedback

Whilst we could address the previous highlighted questions relating to information by coming up with our own solutions for the problem and then testing them with players, it was decided that a participatory design approach would allow a wider range of options to be considered and facilitate conversation with players about operation of hybrid physical/digital game spaces. The participatory design workshop involved eight participants (6 male and 2 female) who played the previously described version of the game 'Antus' . The players were then invited to comment on the current in-game information and then to consider alternate ways of providing that information. These comments were recorded and participants were also encouraged to build physical prototypes of alternate ways of representing this information along with suggestion of new information that could improve overall game play. Whilst systems have been created that allow prototyping of physical game objects (Marco, Cerezo, and Baldassarri 2012) these were aimed at games designers and offer a limited range of ways in which to represent information. Therefore it was decided that providing players with a range of craft materials would allow them to express their ideas much more freely in the given time (Hare, Gill, Loudon, Ramduny-Ellis, and Dix, 2009). A sample selection of some of the produced prototypes is shown in Figures 5 (general feedback prototypes) and 6 (ant queen based prototypes).

This workshop offered many insights into how players approach the problem of physical data representation, and gave people the opportunity to explain some of the less obvious design decisions. The most interesting and relevant insights are as follows.

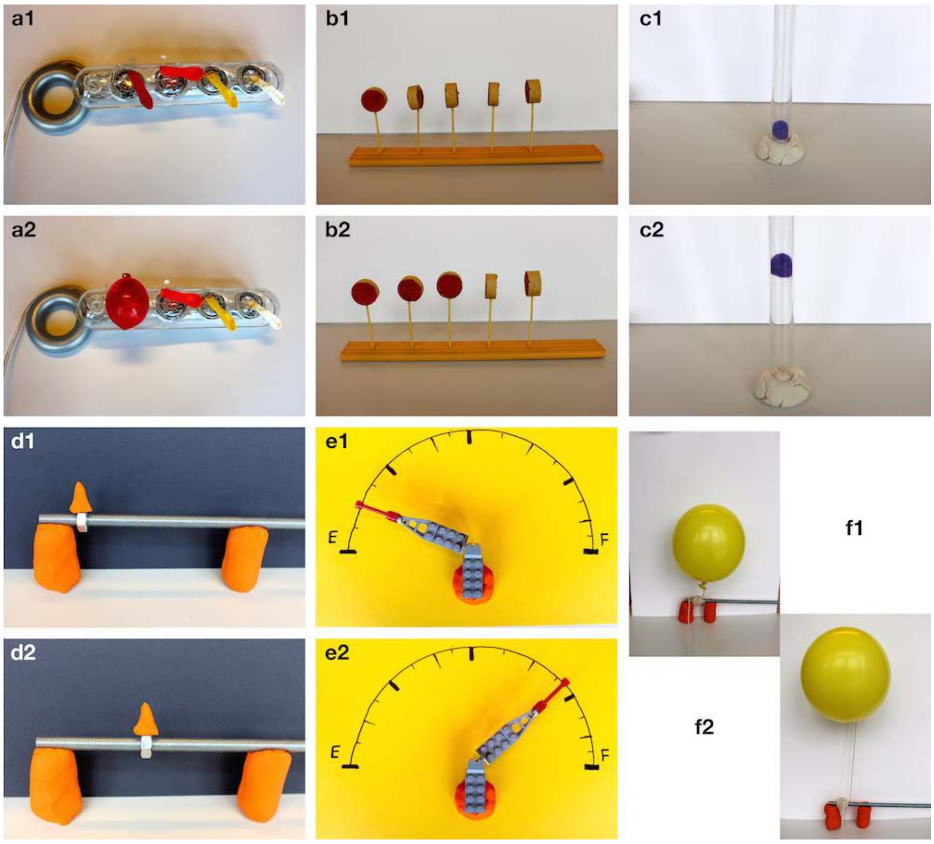

Figure 5. Game Information Prototypes

- Users expected the robot actors to have an emotion and this emotional state has been shown to be important aspect when playing games with them (Barakova and Lourens 2010, Xin and Sharlin 2007) and a number of prototypes built supports this result. Additionally, texture and sound are often related to a state of emotion when used with robotic actors. Most participants chose to use a rough textures and fast noises to represent a negative mood and a smooth textures and slow noises to represent a positive mood.
- The relative difference of information is often more important to users than specific value of the data. Many of the prototypes were designed in such a way that it represented relative concepts such as 'more than my opponent' or 'doing well' rather than to represent specific values to the users. When questioned about this, one participant explained: "the amount isn't important, it's being able to easily see your relative position to your opponent that is important".

Figure 6. Ant Queen Information Prototypes

- 'Glanceable' feedback was important to a number of participants as they wanted to spend more time considering their strategy and playing the game rather than exerting effort to decode the information. Additionally many of the feedback mechanisms were designed as background information – participants did not want to be interrupted to be told the state of the game, and instead want to choose when to get feedback by looking or touching, or have feedback which is more ambient so that they can get a sense for the state of the game. The creator of prototype (5b) said they wanted to recreate "those mechanical displays you used to see in train stations or bus stations" because "you don't have to keep watching them as the noise tells you when something has changed". This noise is effectively an ambient alert that helps bring the information from background to foreground.

- Multiple senses can be used simultaneously to perceive information. For example one participant designed a feedback system that utilised a speaker, LED lights and an inflating balloon to represent different aspect of the game, within one feedback device. The creator explained it was easier to understand than a purely visual feedback device. Often one sense was used as a cue to let the user know that new information is available.
- A scale on a feedback device is not always necessary as some participants chose to not include a scale, and just to represent a state change and a direction.

Whilst some of these prototypes may be used within some of the other game spaces characterised in Figure 2, it does not necessarily follow that they will perceived as the most applicable by players and further prototyping sessions will be needed to explore these alternate spaces. Additionally, it was noticeable that participants were focused on what could be more easily seen, touched or heard as the main channels for feedback, although in later discussions additional senses such as smell were described as possibilities to indicate certain types of information. This may be due to the physical crafting nature of the design workshop - it is hard to represent something as abstract as a smell with a physical prototype.

7. Conclusions

One of the challenges for game designers creating hybrid physical/digital games how they understand the space in which the interactions take place. Starting from the work of Juul we produced four characterisations for physical/digital games spaces described as: Game object; Game objects in player space; Game objects with an interactive surface; and Game objects with screen. We believe these characterisations are a useful way for designers to consider where the focus of the users attention may be, and how feedback is presented to the user. We recognise that these characterisations are by no means a definitive list but as a starting point for designers not only to consider games, but more general interactions in hybrid physical/digital spaces.

The physical prototyping workshop proved an extremely useful way of gaining insights into how players might best be presented with information. One of the main findings of this study is that participants already understood the concept of treating attention as a resource, and were happy experimenting with different senses in order to achieve this. During the course of the workshop, it was often mentioned how many modern designs ignore these physical properties in favour of digital displays.

Not only must a designer consider what kind of information they need to provide, they must also decide whether it is quantitative or qualitative, fixed or relative, a single value or a range. Additionally they must consider what way this information should be conveyed to the user; virtually or physically, visually or kinesthetically.

Whilst this initial study in to the area shows promise, we hope that this and future work in the area produce a 'data representation toolkit' for physical/digital game spaces, something that will aid designers to decide how to represent certain data types, taking in to consideration their data type, urgency and their preferred information bandwidth channel, whilst minimising wastage of users attention. Future work will look into more in depth studies using multiple senses, specifically the more abstract senses such as smell, and testing the viability of the produced toolkit.

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Harnessing the Digital Records of Everyday Things

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Abstract:
We address how, framed by the Internet of Things, digitally-enabled physical objects may acquire rich digital records throughout their lifetimes, and how these might enhance their value, meaning and utility. We reflect on emerging findings from two case studies, one focusing on wargaming miniatures and the other on an augmented guitar, that engage communities of practice in capturing and utilising rich digital records of things. We articulate an agenda for future research in terms of four key themes: How can the digital records of everyday things be captured using both manual and automated approaches? How can these records enhance the embodied use of things in suitably discrete ways? How can people generate diverse stories and accounts from these records? How can we revisit current notions of ownership to reflect a more fluid sense of custodianship? The findings of the studies reveal common emergent themes and preferences of the practicing communities that surround these objects and the above questions, while ongoing participatory and probe studies continue to reveal nuances and evaluate possible approaches.

Keywords: Internet of Things, Objects, Records, Footprints

1. Introduction

The notion of the Internet of Things (IoT) envisions a future in which we are surrounded by digitally-enhanced and inter-connected physical artefacts (Atzori et al., 2012). The IoT has recently become the focus of both intensive academic (Barthel et al., 2013) and commercial (Turber et al., 2014) research and investigation, ranging from new technical capabilities to potential impact on our everyday lives (Fritsch et al., 2011).

One implication of the IoT vision is that these future 'things' will be capable of capturing extensive information about their on-going use. Regardless of the technology employed, the singularisation of objects through unique identification (Koshizuka & Sakamura, 2010) combined with the ability to communicate with both internal and external sensors, inevitably leads to the possibility of everyday things acquiring rich and extensive digital records over their lifetimes (Karpovich, 2011).

The recording the histories of things is not a new phenomenon. Physical artefacts are often documented as being of interest and wonder, whether through personal meaning such as in the case of heirlooms or mementos, or on a broader social level, with cultural artefacts. The resulting records enable us to tell stories about and through these things, ranging from personal, family and social stories to meticulously researched accounts of provenance by the curators of museums and galleries.

However, digital technologies bring the potential to greatly amplify and thereby radically transform such traditional practices (Ahmed et al., 2012; Flintham et al., 2015; Fosh et al., 2013). The digital footprints of things in the future IoT may be far richer, pervasive and persistent than traditional forms of documentation. Indeed, it could well be that the entire existence of future things, from their manufacture through to everyday use by various owners, to ultimate obsolescence, might be charted and examined, or even re-experienced. While this scenario may appear far-fetched, there are already several projects that have been exploring the rich digital footprints, for example Tales of Things (de Jode et al., 2011), and Significant Objects (Glenn & Walker, 2012), as well as various examples of tracked objects such as Book Crossing (Eidenbenz et al., 2013) and Where's George (Brockmann & Theis, 2008; Shlesinger, 2006).

The emergence of things with rich lifelong digital records may give rise to new opportunities for enhancing their value, meaning and ongoing use. It also raises new challenges about what this data reveals about their users and consequently how it is owned and shared among them. With the above in mind we set out to explore two key issues. The first was to understand how 'things' may acquire rich digital records over their lifetimes, meaning that we sought to understand how and why such records are created, maintained and shared. The second was then explore how we might harness these records to enhance the use, meaning and value of these things.

We report on two ongoing studies that explore how two quite different kinds of 'things' – wargaming miniatures and acoustic guitars – can acquire rich digital records over their lifetimes and how these might be put to use. Our particular contribution in this paper is to synthesise perspectives across two previously separately reported studies so as to draw out key themes that need to be addressed by future IoT research.

2. Case Studies

In choosing objects to study we were faced with several challenges. First, our chosen objects would need to have sufficiently complex lives, engaging in diverse interesting activities worthy of detailed record keeping. Secondly, we wished to adopt a lifelong perspective, meaning that we wished to follow such objects from initial creation through phases of active use, changes of ownership and even into ultimate obsolescence.

Our response was twofold. First, we choose our ‘things’ carefully – for example things with active but relatively rapidly unfolding lives. Second, we aimed to find ways of engaging the communities of practice surrounding these, by both bringing them into the process and supporting their existing practices of provenance and record keeping and presentation.

3. First case study: Wargaming miniatures

With the above in mind, our initial search for a suitable type of object led us to consider Wargaming Miniatures, specifically the miniatures involved in Games Workshop’s well-known Warhammer 40,000 franchise (Carter et al., 2014).

These objects display a number of properties that lend themselves admirably to the purposes of the research. First, they are – as physical objects – the product of an extensive crafting process where they are built and hand-painted. Next, the models are tangible representations of narrative elements, as they are based in an extensive fictional background, perpetuated over multiple media such as novels and digital games, were hobbyists draw inspiration from their favourite characters and settings. Parallel to this, they are also tangible aspects of game mechanics, as they are used during gameplay with their ‘tabletop’ capabilities dictated by complex rulesets. This evokes further meaning from their users. The miniatures, or models, appeared to be considered by their practising community as representations of specific identities, skills, abilities, experiences and even separate viewpoints. Initial observations showed the community commonly perceived the models in such ways and went to great efforts to record, maintain and share their provenance and exploits. Models were observed to be sold with accompanying provenance records, which had the apparent effect of boosting their value, both financially and meaningfully.

At this point it was deemed appropriate to perform a deeper ethnographic study of Miniature Wargaming, and the Warhammer 40,000 franchise in particular, to confirm the above suppositions and identify the extent of these provenance practices, the techniques used and the apparent effects they had on the relationship of the hobbyists with the models. The findings of this study where subsequently published in (Darzentas, Brown, Flintham, & Benford, 2015).

In summary, the initial observations that led to the choice of this domain were validated and expanded upon. Three general stages in a miniature’s ‘lifetime’ were identified, crafting, active use in gaming, and display.

The community was found to put great effort in charting and recording the crafting process of their miniatures, keeping journals and documentation and creating blogs to share them with the rest of the community. These included both practical information such as modelling and painting techniques but also more creative content such as backstories and interpretations of how their models would fit into the wider narrative background of the setting, a practice that was directly encouraged by the community.

These efforts continued in the gameplay phase. A common practice among the hobbyists was the creation and sharing of ‘battle reports’. These were textual or video recounts of games using the miniatures. As with the crafting stage records, the reasoning and methods varied widely. Some hobbyists were more interested in creative narrative accounts of their games, while others used the battle reports as a method to analyse and develop their gameplay tactics and strategies. These are a common topic of discussion within the wargaming community, with the verdicts dictating the popularity, in of certain models, armies and strategies.

Finally, the methods that the hobbyists use to display their collections were also considered. As objects of both creative and competitive practices, the models are more often than not considered as prized possessions that the community strives to present and display. On a community level, the models are often the subject of painting and display competitions, were they are arranged in thematic dioramas that present their army and its achievements in some way, as seen in Figure 1 below.

Figure 1 (Left) Typical wargaming miniatures. (Right) Example of an army display board.

The ethnography concluded with a detailed breakdown of the community provenance recording and sharing practices for each stage, and thorough discussion of the emergent themes.

- First, the complexity of the model's 'life' was detailed, highlighting the difficulty of charting it. The non-linear nature of the object's lifetime, meant that conforming to a model would be impractical, and that a deep understanding of the context was needed in any effort of capturing records.
- Next, the methods and types of records were discussed, focusing on how these could be unobtrusively supported with IoT focused approaches.
- Finally, a case was made for the modification and application of the Trajectories framework (Benford et al., 2009) to support the curation of the records.

In keeping with the overall aim of investigating the impact of object's digital footprints, it was determined that the next step would be perform a series of participatory design workshops with experienced gamers in order to design and develop a set of interventions that would support the existing practices of the community, thus introducing IoT paradigms and capabilities to the miniatures but without compromising the core nature of the activity. This final point was considered vital as it was a common theme that emerged from the ethnography, in that the hobbyists, while unanimously open to the idea of technological support and augmentation of the hobby, were wary of altering the core of the hobby.

The Participatory Design workshops led to a number of prototype devices and services, as well as to a number of findings that influence the design of systems that enable the capture, curation and presentation of an object's physical footprint. Among the prototypes were general enabling technologies such as singularising tags, using NFC, and a back-end database and curation service in the form of a website where users could manage and share the content of their object's footprint. The content was actively and passively created by a number of prototypes and designs which included a photobooth device which captured the creation of a miniature, a time-lapse camera setup that captured gameplay and Augmented Reality display boards that enabled thematic viewing of the footprint content.

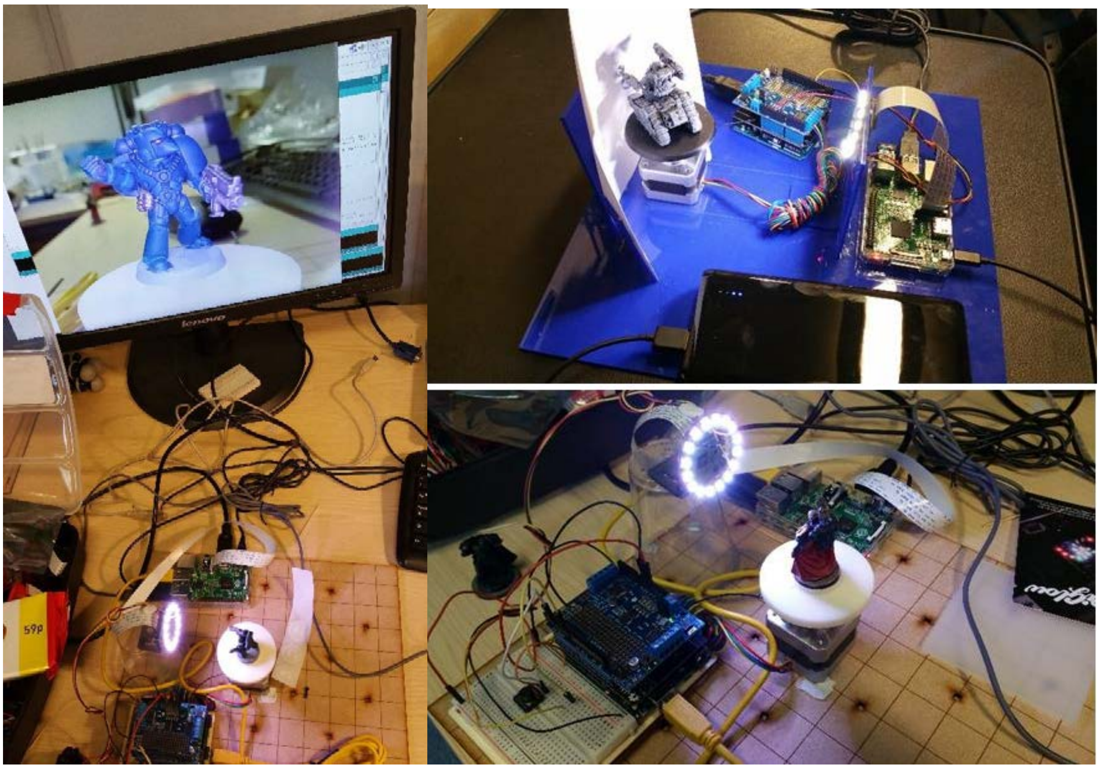

Figure 2 Examples of the capture devices that were developed during the Participatory Design workshops.

The generalizable findings included identifying the tensions between the requirements of the users in relation to the complexity of the footprint, the invisibility of the technology and the desire for information. Additionally, it was found that participants had a tendency and preference, to treat and perceive some of their models as groupings instead of individually. These was found to be primarily for contextual reasons.

4. Second case study: an acoustic guitar

Our second case study involved creating a distinctive travelling technology probe, a digitally augmented 'thing' that could be released into the wild to tour through various settings so as to gather data and engage users in an unfolding design conversation. We chose to digitally augment an acoustic guitar to create an object that would be familiar to many people, valuable, readily portable and that might also gather rich stories through use. We imbued our instrument with a distinct identity in order to establish its uniqueness, naming it 'Carolan' in honour the 18th century Irish harpist and nomadic bard Turlough O'Carolan

Figure 3: The Carolan guitar

We engaged a graphic designer to create a series of six interactive Celtic knot work designs using the Artcodes technology (Meese et al., 2013). These function almost exactly like QR-codes, but are more aesthetically appealing - or beautiful. The patterns can be scanned with a mobile device to conjure up digital information, in this case media from our guitar's digital record. We then collaborated with a professional luthier (instrument maker) to design and hand-build a bespoke acoustic guitar, including inlaying these six designs into different parts of its body – the headstock, fretboard, front soundboard, back, top and in a small nook at the cutaway – as shown in Figure 4.

Figure 4: Scanning the Carolan's soundhole

The second phase was to release Carolan into the wild, building up its digital record as it travelled. Our aim was to engage a diverse set of stakeholders in an inspirational design conversation, jointly exploring the nature and potential value of the guitar's digital record through a deliberately broad series of encounters in diverse settings. We followed a snowballing approach to recruitment, initially drawing on our own contacts with local players, venues and shops but then quickly reaching out through their contacts to engage people further afield, ultimately internationally. We progressed from early engagements where we accompanied Carolan on its travels so as to field-test the probe and seed its initial record to loaning the instrument for weeks at a time. Participants were encouraged to use the guitar as they wished. We then rapidly responded to their design ideas by reconfiguring our app. Participants and researchers jointly documented Carolan's history throughout its travels, capturing a corpus of photos, recordings, notes and interviews and drawing on these to create a series of blogposts (on carolanguitar.com).

We recorded Carolan's design and construction process through documentation ranging from initial design documents, to extensive photographs from the luthier's workshop, to a video of the luthier playing its first ever song. A detailed account of the design can be found in (Benford et al., 2016). We also created an extensive user guide and technical specification that listed the fine details of the guitar's interactive features and construction and these were subsequently updated as a result of various technical set-ups, repairs and routine maintenance occurred, similar to a service log.

The results of this process can be viewed at Carolan's blog at www.carolanguitar.com and a detailed account can be found in the published paper (Benford et al., 2016). The following briefly summarises the key findings.

Initial outings were strongly shepherded, with us accompanying the guitar on short visits with a view to quickly seeding its digital record with engaging materials. We encountered several professional performers as they were touring, introducing them to the guitar and recording interviews in which they reflected on their own instruments and also recorded some songs and tunes, with one being so kind as to introduce and play the guitar during his live show. Subsequent engagements were less shepherded, with the guitar staying in players' homes, typically for a week at a time. Our hosts typically used the instrument as part of their everyday guitar activities including lessons, practice, composing new material and attending clubs and sessions. They captured photographs and videos that were added to Carolan's growing digital record along with material from interviews that we recorded.

We also staged a series of events to explore other activities that might contribute to and also draw on Carolan's digital record, including an open mic session, two recording sessions and a road trip overseas during which our guitar experienced the stresses of international travel. This last engagement provided an opportunity to experiment with deploying additional sensors inside the guitar including an accelerometers and GPS receiver to measure movements, temperature sensors, and an automatic camera placed inside the instrument looking out so as to record a guitar's eye view of the world.

This process of technology probing yielded key insights into the nature and uses of Carolan's digital record. The first concerned the richness of Carolan's digital record that quickly grew to encompass historical provenance; personal and public archives of performances and compositions; guitar stories inspired by Carolan; a user guide including playing and recording tips; a technical specification and maintenance log; playlists to be called up during live shows; materials for lessons; and records of movements and environmental conditions during transportation and storage.

Carolan's digital record added value and meaning to the guitar in diverse ways. One was to enhance its direct use, for example by providing tips on how to best record its voice or by recalling accompanying parts during practice. A second was to enhance its provenance by extending traditionally sparse provenance records with rich details of who had owned, played and maintained it. A third was to inspire players to create meaningful compositions and stories to be associated with the instrument. Finally, the digital record became the nub of a social network of people who were associated with the instrument in different ways and who wished to follow its progress as it travelled to meet new players.

Recognition of potentially diverse uses for the digital record revealed a requirement to support complex and dynamic mappings between the instrument and its associated digital media. Thus, each person who borrowed or played Carolan r might require a personalized experience such that scanning its various patterns would connect them to those parts of its digital record that reflected their own interests or history. These mappings might then become dynamic, varying according to the times and locations of particular events (the guitar might conjure up different playlists of tunes at different sessions or gigs). Moreover, each such mapping – for a particular person at a particular event – might also address different audiences, for example delivering specific information to the current player and different information to any audience members that scanned it.

We therefore extended Carolan's software to allow users to create, modify and share personal and event specific mappings between the physical instrument and its digital record. While in principle, any of the six interactive surfaces of the guitar might be mapped to any information from the digital record, a convention gradually emerged in which specific surfaces tended to be reserved for particular purposes. Three surfaces became relatively fixed in their associations. The headstock (traditionally the site of the maker's logo on a guitar) tended to remain connected to official provenance information. The top sound hole (mostly visible to the player) tended to be reserved for the user guide. The fret board code that could only be scanned when the strings were removed was reserved for the technical specification and maintenance log. The remaining three surfaces were employed more flexibly. The front was often seen as public voice of the instrument to be associated with personal and event specific playlists, the small code in the cutaway was reserved for bonus material that rewarded close inspection, while in contrast the back offered a general purpose surface that could be scanned from several meters away. Thus, we learned that the mappings between interactive decorated physical things and their records are complex, multi-purpose, address diverse audiences, depend on the physical affordances (visibility, access and cultural meanings) (Norman, 1999) of their different surfaces and need to be dynamically tunable to different owners and contexts.

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3. Discussion

We now draw on our two studies to identify common issues and challenges concerning the design of future practices and enabling technologies for connecting everyday things with digital records so as to enhance their use, meaning and hence value. We group these under four broad themes concerned with:

- how humans and sensing technologies combine to capture rich digital records of things;
- how these records can be drawn on in suitably discrete ways to enhance the situated use of things;
- how they can also support the telling of diverse stories, from verifiable accounts of provenance to fictional narratives;
- and finally how we need to extend simplistic notions of ownership to cope with more complex natures of custodianship in which different stakeholders assume rights and responsibilities for the digital record over a thing's lifetime.

5.1 Capturing the Record

Our studies reveal that the digital records of things can be rich and complex, comprising various forms of data from sensor data logs such as GPS positions and environmental sensors, to records of people's interactions, to multimedia documentation of both creation and use. Thus a wargaming miniature becomes associated with extensive documentation of its construction and painting as well as statistics arising from gameplay and a guitar becomes associated with documentation of performances but also streams of sensor data about temperature and movements.

The capture and curation of such a complex digital record demands the involvement of humans throughout the entire data chain, from initial acquisition through to interpretation. As well as thinking about how people might visualize or otherwise interpret data, we also need to address how they become intimately involvement in its capture. While embedded sensors might help capture unusual perspective on a thing (e.g., internal stresses and strains) or provide insights into a thing's life away from its owners (e.g., when in transit), the deployment of sensors requires direct human intervention. By becoming owned and used, a miniature, guitar or any similar thing becomes more than just a product to be tracked through a manufacturing and distribution process. It now becomes an artefact that occupies human environments capturing everyday activities. Some of these environments and activities are private or sensitive requiring human intervention to enable, disable or even removing sensors. A thing may also wish to gather data from sensors outside of itself in the surrounding environment which may require negotiation with or intervention from those responsible for that environment. Finally, humans may simply enjoy capturing documentation and data as part of creative and social practices. Just as people enjoy painting miniatures and playing guitars so they may enjoy filming these practices and sharing them with others through social media. This enjoyment may extend beyond direct participants in the practice to spectator, audiences and aficionados. In short, while embedded and automated sensors may certainly thicken the digital records of things, we need to recognize from the outset that capturing these records will remain a hands-on human process.

5.2 The situated and embodied use of the digital records

Our case studies reveal various ways in which digital records, once captured, can enhance the situated use of a thing. They may provide guidance as to how to use the thing, reaching far beyond traditional user guides to instead offer contextually appropriate recommendations. Thus, a guitar may recommend 'tunebooks' for a particular jam session while a miniature may provide information to support tactical planning in battle with demonstrable effectiveness metrics and analyses of previous games and strategies. In a similar vein, digital records may support learning and practice. Carolan's players suggested that a guitar might conjure up appropriate pieces to learn, capture players' attempts or even play accompany them by playing back recordings of other musical parts. Similarly for wargaming, one of the prime motivations for creating and consuming Battle Reports was for hobbyists to analyse performance. Finally, the thing may integrate recorded materials from its digital record with live use, enabling participants to replay and manipulate past recordings or play along with them. Carolan's open mic session involved summoning up recordings by previous performers in the gaps between live performances while the idea of playing along an accompaniment above fits naturally with the recent growth of interest in live 'looping' in musical performance, supported by cheaply available looping pedals.

While these ideas suggest various opportunities for drawing on the digital record to enhance the direct use of a thing, our case studies also revealed significant challenges in the areas of appropriately situated and embodied use. Proposals to augment the in-game use of wargaming miniatures proved controversial with participants as, even though they were desirable, they were seen to potentially interfere with the core of the wargaming practice. Not only might they infringe the official rules, but might also break established social norms, or simply interfere with the moment of play. Similarly, the need to continually document the construction and painting process was seen by some as interfering with the craft and pleasure of the experience.

These observations relate to two wider concepts. The first is the notion of flow that describes a particular mental state arising from the proficient performance of embodied skills such as playing a game or a musical instrument (Csikszentmihalyi, 2008; Gregory, 2008). Flow states are considered to be immersive and pleasurable and perhaps even the ideal goal state for such pastimes, so that activities that break flow, for example having to stop to record or access some data, or being pulled back into a more reflective mode by thinking about past performances, may become problematic. Second is the idea of situated discretion that (coincidentally) was articulated as a result of previous studies of traditional music sessions (Benford, Tolmie, Ahmed, Crabtree, & Rodden, 2012). The social norm of such sessions is to play music in the traditional way "by ear". While making reference to crib notes and supporting materials may be acceptable if suitably discrete, any technology that serious subverts the social etiquette may be poorly received. Attempts to use the digital record to augment the use of 'things' – especially meaningful ones that demand skilled use – will need to respect the embodied and social nature of use that are inherent in concepts such as flow and situated discretion.

5.3 Generating stories and accounts from the record

The digital records of things also have the potential to enhance their meaning and value beyond their immediate use by enabling people to generate various forms of narrative. Once again, the twin cases of wargaming miniatures and the Carolan reveal how broad these can be. At one extreme are stories concerned with the provenance of a thing in which the digital record is used to establish its identity and determine the veracity of a claimed history. This may draw on records of the creation of the thing such as the assembly and painting of miniatures and design and construction of a guitar in the luthier's workshop, but also extends to records of subsequent modifications, maintenance and also use. Guitars, for example, can acquire extremely high financial values if provably owned and played by famous musicians. At the other extreme lie more fictional 'stories' that adopt the thing as an inspiration or mechanism for storytelling. Wargamers publish blogs around the exploits of a character while composers adopt a guitar as the muse for composition.

The need to support such a diverse range of narratives, created by different people for different purposes, raises the challenges of how the digital record of a 'thing' can be shared among a community of users so that they can create personal narratives as well as how the thing itself can be mapped onto distinct stories in different situations. Augmented reality and embedded computing technologies allow a physical thing to be queried so as to deliver up digital information. Our case studies suggest that each thing may need to be mapped onto potentially many stories that can then be triggered according to the specific audience, purpose and context. For example, reading an embedded RFID sensor in a miniature may trigger different stories depending on whether it is at the gaming table (in which case we might be interested in verifiable history as part of applying the rules of the game) versus being in a display cabinet (where we might be interested in more fictional stories) while augmented-reality style scanning of the Carolan might reveal its official provenance when in a shop but link to personal compositions of its current player at a gig.

5.4 Ownership of the record

Implicit in all of the above is the notion of ownership and rights; that different 'users' as we have been calling them up to now have the ability to contribute and draw on parts of the digital record of a thing and to map the thing onto to their own personalized narratives. Our final theme therefore reflects more deeply on this notion of ownership. Our case studies reveal that the ownership of the thing itself may be complex. Both guitars and miniatures have makers who retain a degree of ownership over their design and brand, legal owners and possibly more temporary 'owners' who may be playing with them a particular moments, all of whom might be different individuals or even groups. The complexities of ownership extend beyond the physical thing itself to its digital record which may introduce further owners into the picture, for example spectators, audiences and even venues who may contribute information and data over which they retain rights.

Given these complexities, it may be more sensible to speak of notions of custodianship rather than ownership; that a thing typically has multiple custodians who adopt different relationships to it and who may contribute to and draw on its digital record. A key challenge is to establish ways for these custodians to share rights in and credit for the digital record, perhaps in our cases through creative commons (Benford et al., 2016). This sharing may prove especially tricky when we adopt a lifelong perspective on the thing as this leads us to consider transitions of custodianship. How is the digital record managed as custodians come and go? Are current custodians responsible to upkeep of the past digital record (as they are with upkeep of the physical thing)? Which aspects of a thing's past record can current custodians access? Can previous custodians retain access to their own digital records of the thing even after it has left them? Might they even somehow have acquired rights to be able to see what happens to it in the future? Such questions may be challenging enough when applied to creative objects such as wargaming miniatures and guitars, but are likely to prove extremely thorny when we consider more 'sensitive' personal objects. What rights might the various custodians of a car or a house have over its digital record during and after their custodianship? Can the new owner of my car verify that I was indeed a careful owner? Can I still access my personal memories of living in a previous house? We propose that these questions form an important agenda for further research into the lifelong digital records of everyday things.

4. Conclusions

In summary, reflecting across two ongoing projects to digitally enhance things with rich digital records that might enhance their value, meaning and use, has revealed a common research agenda for future IoT research. This comprises three key questions: how can the digital records of things be captured using a combination of manual and automated approaches? How can these records then enhance the embodied use of the thing is a suitably discrete way that respects its context of use? How can we enable people to generate a wide variety of stories and accounts of the thing from its record? And finally, how can we revisit current notions of ownership to reflect a more fluid sense of custodianship, both of the digital record as well as of the thing itself. Further work in both settings is set to continue, with the ultimate aim of potentially generalising the findings into wider and different contexts and domains.

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A Toaster For Life: Using Design Fiction To Facilitate Discussion On The Creation Of A Sustainable Internet of Things

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Abstract: This paper presents a design fiction created by the author – the *Toaster For Life*. The design is an initial prototype that seeks to embody Sterling's concept of *spimes* which when viewed simply, are a class of near future, sustainable, manufactured objects designed to make the *implicit* impacts of a technological product's entire lifestyle more *explicit* to its potential users. This paper argues that when properly understood, spimes act as a rhetorical device that can be used as a lens through which designers can speculate and reflect upon sustainable technological product futures whilst also critiquing the unsustainable production and consumption practices that define our current lifestyles. To make this case, the paper contextualises the *Toaster For Life* in relation to the spimes concept, the unsustainability of Internet of Things products and sustainable design praxis; and reflects upon the design fiction methodology used to highlight the potential benefits of such an approach.

Keywords: spimes; sustainable product design; internet of things; design fiction

1. Introduction

The term *spimes* was coined in 2004 by the futurist Bruce Sterling to denote a class of near future, sustainable, manufactured objects. Sterling (2005, p.11) envisions spimes to be "material instantiations of an immaterial system… they are designed on screens, fabricated by digital means and precisely tracked through space and time throughout their earthly sojourn." In a spime-based future, products, objects and things would be materialised nodes, physical anchors to an expansive, networked digital domain. Taylor & Harrison (2008, p.345) note that the significance of a spime would be "not so much the physical material object [but] the provenance, history" and informational support system that it creates. In essence, a spime object would be "a set of relationships first and always, and an object now and then" (Sterling, 2005, p.77).

Today, electronic product waste (e-waste) is said to be the fastest growing waste stream in the world, while the material resources needed to manufacture such products are becoming ever more scarce (Webster 2015). *Internet of Things* (IoT) products continue to adhere to these unsustainable models of production and consumption, and the time is therefore right to explore Sterling's concept in greater depth. The origins of spimes are *in the present* as they are likely to develop out of today's technological product culture. Having done so, their earliest 'material instantiations' would share some common attributes with current technological products, for example, location aware (GPS), networked (wireless mobile Internet) and environment sensing (embedded sensors/actuators) capabilities. This has led some to use *spimes* and the *IoT* interchangeably to denote an Internet-connected object. I argue that this is a fundamental misappropriation of Sterling's term. The informational support afforded by IoT products centres on the 'use phase' of their lifecycle – for example, the display of energy usage data – and fails to account for their inherent materiality. In contrast, a spime object would be designed so that it can be managed sustainably by its users throughout its entire lifecycle – from initial design through its use phase to its rebirth as a future spime object ad infinitum.

To frame the spimes concept, Sterling (2005) traces the evolution of what he calls our 'techno-culture' – the relationship between people and their material things. His analysis moves from 'artifacts' (farmers' tools) to 'machines' (customers' devices) to 'products' (customers' purchases) to 'gizmos' (end-users' platforms) to beyond, to what he considers a preferable future defined by *spimes*. Sterling asserts that techno-cultures prior to 'gizmos' had simpler, more linear sets of relationships. He notes how 'artifacts' were self-made or made by those living in close proximity, and enabled people to live off the land. As a result, people were more aware of the provenance of their objects and the effects such tools, and the work they facilitated, had on the immediate environment. This transparency became extremely muddied in the transition to our present day 'gizmo' techno-culture due to an overreliance on increasingly complex material extraction, manufacturing, supply chain and consumption infrastructures. Sterling asserts that our relationships with 'gizmo' products are highly mediated and *unstable* - we are now *end-users* who are denied the fundamentals of product production and disposal.

I contend that whereas today's 'gizmo' products will eventually be discarded and enter the electronic waste stream with their precious materials and embodied energy forever lost, *spimes, by their very nature, would be an ongoing means rather than an end*. One would know where a spime object has come from, where it is and where it is going. Like Sterling, I posit that this innate transparency would radically alter how people use and value their material things. Thus, while the *present* might be described as a 'transitionary period' from unsustainable IoT 'gizmos' to sustainable spime objects, we are yet to definitively begin designing, manufacturing and consuming the latter. Moreover, as Maly (2012, para.22) stresses, spimes can only come to be if the products "getting manufactured [are] as easy to dispose of as [they are] to make." The concept of spimes, then, is both *ideologically of the future* – a manifesto for moving beyond the unsustainable people-product relationships of today – and *pragmatically of the future* – as the physical, infinitely recyclable materials required for spimes' sustainable existence are yet to exist.

2. Spimes As A Lens For Speculation And Reflection

Hales (2013, p.6) describes the concept of spimes as "rhetorically futuristic… a category of imaginary object that is also an intervention in the present and [which] are 'forward looking' akin to the actually futuristic objects they create." As outlined, whilst early spimes may come about through extrapolations and convergences of today's technologies and creative practices, we are as yet unable to 'actually' design and produce spimes. We can, however, use speculative design methods to envision potential near future worlds in which spime objects might exist as well as to explore the types of people-product relationships spimes may possibly facilitate. If Sterling (2005) provided the initiatory theoretical underpinnings for the 'rhetorically futuristic' construction of spimes, I contend that the speculative design methodology *design fiction* can, in turn, provide the most appropriate method for envisioning 'actually futuristic' spime objects.

Having coined the term spimes, Sterling (2005) also originated the term design fiction and has since defined this method as "the deliberate use of diegetic prototypes to suspend disbelief about change" (cited in Bosch, 2012, para.3). Here he is appropriating Kirby's (2010) notion of 'diegetic prototyping' which denotes how a futuristic object or product might be rendered 'material' and fully functional in 'diegesis', in other words, as a 'prop' embedded in a fictional narrative environment or 'storyworld'. As Tanenbaum (2011, para.5) states, the positioning of the designed object within a fictional frame is central to the method as it enables designers to "make an argument about a potential future by demonstrating that future in a context that a large public audience can understand." Design fictions should therefore not be seen as an attempt to predict the future or design a specific 'product solution' but as a strategy for opening up inclusive debate about *how* and *why* futures are designed and what they might mean. They aim to create a discursive space in which the design prototype is free of the constraints of normative commercial design practice and can challenge peoples' insular and habituated perceptions and expectations of the role products and services play in their everyday life (Bleecker 2009).

Unpacking Sterling's spimes concept, Stead (2015) puts forward seven potential design criteria for near future spime objects:

- Context;
- Technology;
- Sustainability;
- Temporality;
- Metahistory;
- Synchronicity;

- Wrangling.

The *Toaster For Life* is a 'diegetic prototype' which aims to embody three of the above spime design criteria – 'technology', 'sustainability' and 'temporality.' The design (Figure 1) represents an early material instantiation of a spime object; a physical product with innate sustainable attributes including the ability to be repaired, upgraded, customised, recycled and tracked throughout its lifecycle. By presenting a spime as 'actually futuristic' within a fictional world, I hope to provoke audiences to consider the potential implications, meanings and values that spimes may bring and also question whether such a future offers a more 'preferable' alternative to our present day methods of production and consumption. In addition to this, I have also found the conception of the spime-based design fiction to be an inherently reflective process. Sterling (n.d, para.4) also acknowledges this, stressing that, "the best way to understand the many difficulties of design fiction is to attempt to create one." Accordingly, I see spimes as a lens for speculating and reflecting upon alternate worlds in which sustainable technological products exist – both for the audiences that designers seek to their work to engage with and the designers who seek to envision them.

Figure 1 The 'Toaster For Life' represents an early 'material instantiation' of a spime object – a physical product with innate sustainable attributes. I see 'peripheral' material such as this 'product launch brochure' as one way of helping to build a world in which spime objects are 'actually futuristic', in other words, appear as if they 'exist.' Other designers use a variety of media to build speculative worlds including artefacts, films, digital games and text.

3. Spimes And Design Fiction

The nascent method design fiction shares similarities with the more established field of *critical design*. Dunne & Raby (2007, para.1) describe the latter as the opposite of 'affirmative' commercial industrial design practice, which simply "reinforces the status quo." Seeing confusion arising from the different terminology, Auger (2013) advocates the use of *speculative design* as an 'umbrella' term for these related envisioning methodologies. Auger's term is useful and allows for easy interchange between the two methods. Nevertheless, I argue that it is design fiction in particular which engenders speculative proposals with characteristics that are key to the envisioning of spimes. Design fiction and spimes are both emblematic of Sterling's (2005, p.5) interest with *time*, encapsulated in his comment: "why things were once as they were, why things are as they are, and what things seem to be becoming." I posit that Sterling introduces the concept of spimes to symbolise this *atemporality* and design fiction as *the* method for concretising it. In this sense, spimes are representative of design fiction and likewise, design fiction is central to the representation of spimes.

3.1 Futures Mundane

Design fiction is often discussed in relation to science fiction literature and film, not least because Sterling is a noted science fiction author but also due to the use of diegetic prototyping, which is rooted in the ways in which new technologies are introduced and 'actualised' within the narratives of Hollywood science fiction films (Kirby 2010). Whilst not seeking to discredit its influence upon the method, I argue that spimes are best framed in relation to mundane, everyday objects as opposed to the fantasy and spectacle often used to present science fiction style technologies. Foster sees the juxtaposition of possible new technological products in relation to past artefacts as an effective way of framing mundane futures:

> "We should embrace legacy technologies when conceiving new ones… to show potential disconnects between the new and established, places where technology sticks out like a sore thumb. This is a useful tool for all designers and using it well can help us depict a more tangible future." (Foster, 2013, para.14).

Sterling (2005) begins to do this by describing how a near future spime object might manifest as a bottle of wine. Other design fictions such as the short film *A Digital Tomorrow* (Nova et al, 2012) and those presented in the Bleecker edited *To Be Designed Catalog* (2014) pose similarly mundane near futures. The *Toaster For Life* proposal expands upon this approach by contrasting a near future spime product with a banal and ubiquitous domestic electronic object of today.

Similar to Foster, Auger (2013, p.12) contends that one must ensure "careful management of the speculation; if it strays too far into the future to present implausible concepts… the audience will not relate to the proposal." The *Toaster For Life* design extrapolates a range of present day technologies, practices and behaviours and marries them with fictitious possibilities including domestically 3D printable eco-plastics and 'nano-RFID' tracking capabilities (Figure 2). This projected convergence would result in new spime-like people-product practices and interactions. In light of this, rather than attempting to design a radical ‘game-changing’ spime product, I have chosen to embody the spime concept in an object that a mainstream audience beyond academia will readily relate to – the humble toaster. I hope that the unfamiliar practices and interactions afforded by a *spime toaster* appear mundane, ‘everyday’ and, most importantly, plausible. This may lessen the potential for the product’s features and technologies to appear fantastical, unreal or as Auger implies – ‘too futured’. Further, the framing of spimes in relation to a mass-produced artefact also facilitates critique of the unsustainability of IoT products. Increasing material scarcity and e-waste are evidence that we often take commonplace objects like toasters for granted. How long will it be before we throwaway more our mundane products and replace them with IoT style devices? Will these connected products be any more sustainable?

Figure 2 A ‘Synchron nano-RFID tag’ and tags in situ attached to parts. One of several fictional sustainable attributes within the speculation, these tags would be fitted to the majority of the toaster’s parts allowing components to be tracked throughout their lifecycle.

3.2 Sustainability and the Everyday

The proposal not only seeks to embody a near future spime object but also make the oftentimes abstract concept of electronic product sustainability more practical and tangible to a variety of audiences. The issue of environmental sustainability is often framed within utopian or dystopian narratives. I argue that, rather than engaging audiences, these extreme visions disengage people from taking part in this important dialogue. Accordingly, I have purposely sought to avoid presenting the speculation as an ‘idealistic utopia’ or ‘end is nigh' style dystopia. Situated in the mundane, the *Toaster For Life* aims to make sustainability more of an 'everyday concern'. This aligns with Sterling's (2005, p.30) view that a design fiction is most successful when it presents new products and technologies as "practical [and] more hands on."

I contend that the use of what Hales (2013) calls 'new media' can also help to bring the sustainability of everyday objects into sharper focus. Whereas art galleries have played a significant role in the dissemination of critical designs, design fictions more actively "encourage debate using social/viral media and popular culture" (MIT MediaLab, n.d, para.2). The appropriation of such media can extend the 'reach' of a design fiction, enabling the proposal to 'speak' to audiences beyond academia, the design sector and artistic elite. Moreover, their playful subversion of marketing material and advertising promo films – the media most associated with 'real' industrial product design – often means that design fictions do not require in-depth *pre-text*. Unlike critical designs whose 'readability' can be undermined by their gallery context and academic framing, audiences are well versed in the *semiology* of design fictions, they can already 'read the signs.' This inherent readability is crucial for the *Toaster For Life* proposal as audiences do not have to negotiate a 'layer of theory', they can instead consider the most significant aspects of the design – its sustainability and how this relates to their day-to-day lives.

4. Crafting The Design Fiction

Alongside the increase in proprietary IoT 'gizmos' such as smart phones, wearable fitness trackers and wireless energy monitors, recent years have also witnessed growth in decentralised IoT practices like the Maker Movement, 'hacking', Fab labs and open hardware and software development. Within these sub-cultures, people use technologies like RFID, computer-aided design software and 3D printers to design and build bespoke Internet-connected objects (McEwen & Cassimally 2013). I contend that it is within this latter strand of technological product development that Sterling identified potential for a more sustainable material culture. The *Toaster For Life* speculation might be seen as a means of reassessing the above technologies and practices to potentially realign them with Sterling's sustainable vision as opposed to the corporate rhetoric of the IoT.

Stead (2015, p.6) posits that the earliest, material instantiations of spimes would likely be characterised by a convergence of the following six technologies and practices:

11) RFID tags – Small, inexpensive means of remotely and uniquely identifying a spime object over short ranges;
12) GPS – A mechanism to precisely locate a spime object on Earth;
13) Internet Search Engine – Search functionality affording a front end to mine the enormous amounts of data that a spime object is constantly collecting and transmitting;
14) CAD Software – Tools to digitally construct and manipulate endless iterations of a spime object;

15) 3D Printers – Sophisticated, automated and robust means to rapidly fabricate a 'digital instantiation' of a spime object into a 'material instantiation';
16) Eco-materials – Materials which are ecologically safe and durable but also highly versatile. When a spime object is no longer required, they can be cheaply returned into the production process as a raw material for future spime objects.

Yet, if many contemporary unsustainable products are designed and manufactured using the above, how would the lifecycle of an early spime be made potentially more sustainable with similar technologies/practices? Bonnani et al (2009, p.265) suggest that the design of spime objects would rely "on a life-cycle approach… to account for materials and energy over multiple generations. [This] could empower a tinkerer to repair a product; it could offer information about available upgrades and customization; and as technology evolves… could provide new strategies for re-use and recycling." Figure 1 and Figure 3 show the front cover and an internal page of a 'product launch brochure' for the *Toaster For Life* design fiction. In contrast with the toasters of today, the speculative toaster has been designed to allow potential users' to sustainably manage its lifecycle by partaking in effective product *repair*, *upgrade, customisation*, *recycling* and *tracking* practices.

Near future eco-materials would make the material instantiations of spime objects infinitely enhanceable. People would have flexibility to dispose of their material spimes quickly, cultivate longer-lasting relationships with them through care and maintenance, or practice something in-between. Thus, "rather than forever remaining the same… spimes would have the innate ability to transform and reflect changes in technology, cultural trends and peoples' needs" (Stead, 2015, p.9). With this lineage to past, present and future product cultures, a spime object would be *atemporal*. I therefore chose to title the design *Toaster For Life* as it connotes notions of time. Atemporality is also reflected in the use of the design fiction method itself. The 'actually futuristic' spime toaster is 'materialised' within a fictional future world and is therefore asynchronous to the present. Despite this theoretical rationale, in my mind *Toaster For Life* does not require specific pre-text. It does much to convey the concept of product longevity and sustainability without academic explanation. As a result, I hope the title will also help the speculation to engage broader, non-academic audiences.

As has already been noted, 'plausibility' is the principle reason for representing the spime concept as a toaster. Toasters are a staple of the domestic setting, of routine interactions. In addition to this, the 'toaster', like the 'fridge', is often cited as an archetypal IoT device, an everyday product that, if made 'smart' and networked, would enrich its users' lives in new and beneficial ways. Sterling (2014, p.19) laments this corporate rhetoric where the connection between the physical material object and the digital world is often being made

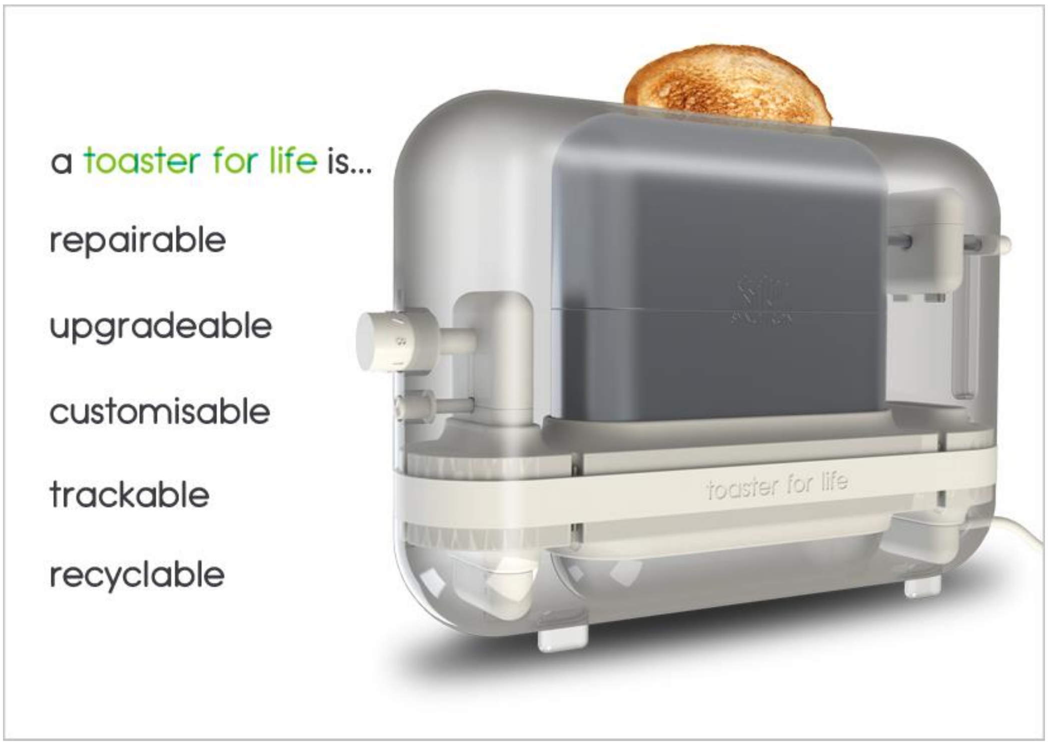

Figure 3 The key spime-like sustainable attributes of the Toaster For Life presented in the speculation – repair, upgrade, customisation, recycling, and tracking. In addition to these features, the prototype has been designed to function like any present day existing toaster, that is, to toast bread.

for connection's sake – "making your refrigerator talk to your toaster is a senseless trick that any competent hacker can achieve today for twenty bucks." The *Toaster For Life* seeks to subvert this rhetoric by shifting emphasis away from the production and consumption of superfluous connected gizmos and instead focusing on the responsible and sustainable ownership of ubiquitous electronic objects. In modern western societies, toasters, like many other domestic electronic products, are often seen as disposable. If such a product breaks in some way, it can be more cost effective and convenient to purchase an entirely new product rather than to the spend time, energy and money trying to repair the original artefact, either personally or through professional means. Most proprietary electronic objects make use of glues, screws, hidden seals and irreplaceable parts. They are purposely designed to be difficult to maintain and upgrade, forcing people to buy a newer iteration when their current device ceases to function correctly (Slade 2007).

The *Toaster For Life* should not be seen as a potential 'solution product' to the unsustainable issues described above, but as a means for generating discussion about those issues. Bleecker outlines this distinction:

> "Design fiction objects are totems through which a larger story can be told, or imagined or expressed. They are like artifacts from someplace else, telling stories about other worlds." (Bleecker, 2009, p.7).

Nevertheless, I argue that in order for the world in which the *Toaster For Life* exists to appear plausible and engage audiences effectively, the 'design fiction object' itself must also *appear* plausible, that is, *seem as if it had actually been designed and could be manufactured*. With this in mind, the process of designing the spime toaster was more intricate and time-consuming than I had first anticipated. What appears to be a relatively simple and banal object grows increasingly complex when one begins to consider integrating several sustainable strategies into its design. Furthermore, uncertainties arise when designing for a combination of materials and technologies that presently do not exist. These issues also impacted the adoption of Stead's (2015) spime design criteria. Rather than including all seven in this first speculation, I made the decision to focus on the design potential of only three of the criteria – 'technology', 'sustainability' and 'temporality'. I felt that this combination would 'do enough' to convey the sustainable credentials of an early material spime object without losing the essence of Sterling's concept.

I began the design process by gaining a greater understanding of the design, manufacture and provenance of an existing toaster (Figure 4). As a result of this analysis, I considered using the purchased product as the template for the speculative iteration (Figure 4 – right) depicts my initial CAD model. I soon realised, however, that in order to accommodate various spime-like attributes, I would have to rethink the design in a more holistic manner. As illustrated by Figure 5, several different iterations of the prototype thus followed. The ensuing *Toaster For Life* prototype has been designed to toast bread (Figure 3), but unlike other toasters, it would also afford self-repair and upgrades due to its modular design (Figure 6). Using sustainable design strategies *Design-for-Disassembly* (Chiodo 2005) and *Design-for-Recycling* (Gaustad, et al 2010) as reference, I have integrated accessible parts and efficient component separation into the toaster's design in an attempt to allow more effective repair and recycling by potential users. No glues, screws or hidden seals are featured. Modularisation is said to extend product lifecycles and reduce use of materials, energy, packaging and distribution emissions (Greenpeace 2014). Upgrades to inner componentry would also be possible because the design would operate via modular open source hardware and software (Figure 7). It is common for electronic components to be soldered directly to printed circuit boards making them immovable without the correct equipment and expertise (this is the case with the purchased toaster). The *Toaster For Life* design incorporates solderless breadboards allowing components to be simply exchanged if they break and/or upgraded should new functionality become available.

Modularisation and open source technologies like *Arduino* are seen as tenets of democratised and decentralised 'making' and 'hacking' cultures. Indeed, such techniques are central to Make Magazine's influential *Owner's Manifesto* (Torrone 2006). In recent years, modularization has been subject to increased interest within the mobile phone sector where manufacturers have been heavily criticised for perpetuating planned obsolescence. While the highly publicised *Google Project Ara* phone and independent projects *PhoneBloks* and *PuzzlePhone* remain in the development stages, responsible manufacturer *Fairphone* has brought two modular smart phones to market. Each of these four projects is pictured in

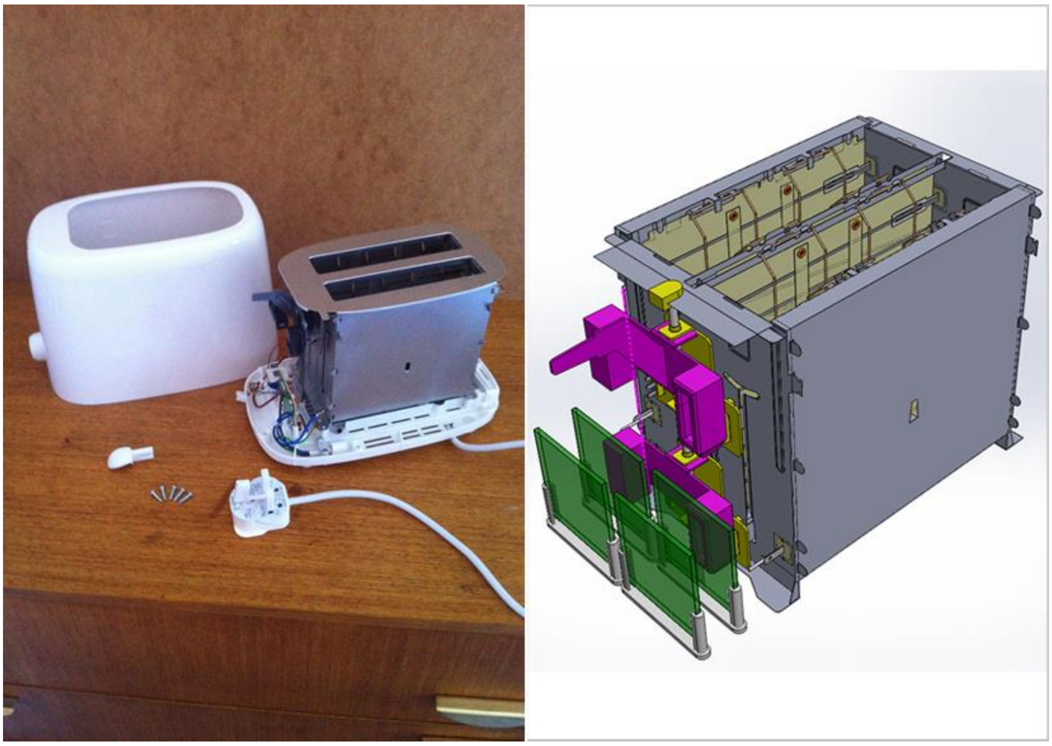

Figure 4 Left – The existing toaster that I purchased and deconstructed; right – my initial CAD model based on the purchased toaster.

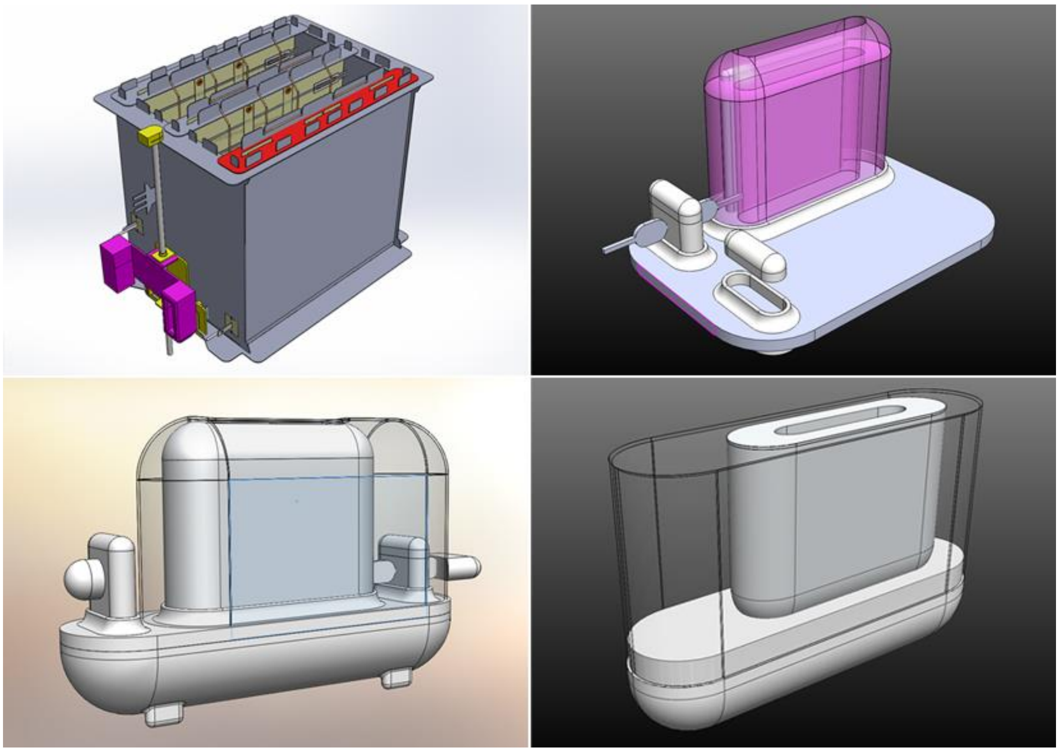

Figure 5 Successive iterations of the Toaster For Life prototype.

Figure 6 The prototype's design is modular with no screws, glues or hidden seals. Users would therefore be able to easily disassemble the toaster.

Figure 7 The design would operate via modular open source hardware and software. Here the solderless breadboard allows easy replacement/repair of componentry should any parts break. The 'Berners-Lee 3' micro-processor board's wireless and geo-locative functions enable the product and its parts to be tracked.

Figure 8 A range of modular smart phone concepts. Clockwise top left to bottom left – Fairphone, Google's Project Ara, PhoneBloks and PuzzlePhone (all 2015).

Figure 8. In the main however, open source and modular approaches are yet to be adopted into the design of most mass-produced proprietary consumer electronic appliances, despite growing calls to do so from ethical organisations such as Restart (2015) and the Great Recovery Project (2013).

The *Toaster For Life's* modular design and use of would-be eco-materials would also enable users to recycle, customise and track its individual parts. The speculation implies that CAD and domestic fabrication have become mainstream activities in the near future. Aluminium and heat resistant bio-plastics would be readily accessible for home 3D printing and both materials could be efficiently and repeatedly recycled (Figure 9). Domestic fabrication would also give people the freedom to customise their spime toaster as and when they please, perhaps altering the colour of the product's casings (Figure 10) or even adding an additional toasting chamber. The proposal further frames the product as inherently trackable due to the majority of its parts being fitted with nano RFID tags; a smaller but more powerful iteration of today's radio frequency technology (see Figure 2). This would enable potential users to ascertain the whereabouts of individual componetry throughout the product's entire lifecycle. Data from each part would be stored on the attached tag. When tagged parts are within the required proximity, their data would be transmitted from their tag to the *Synchron Berners-Lee 3* micro-processor board (see Figure 7). The *Berners-Lee 3* would be equipped with wireless and geo-location abilities and would therefore be able to continually log details online about the toaster's current state of operation. Similar 'synching' interactions would occur at different stages of each part's lifecycle, for example, at manufacture, points of distribution, during usage and then finally at disposal when they are returned to Synchron – the fictional environmentally conscious manufacturer of the *Toaster For Life* – for recycling and reuse in the production of future spime products.

The *Toaster For Life's* aesthetic sensibilities also seeks to reflect sustainability, namely notions of 'openness' and 'transparency'. Regards the product's clear casing, I was inspired in part by Daniel Weil's 1981 design *Radio In A Bag* (Figure 11 - left) but more so by a range of consumer products made by Freeplay. Housed in transparent casings, the manufacturer's radios and torches (Figure 11 - right) are extremely popular in developing nations, where self repair, customisation and 'off the grid' cultures are, by necessity, more prevalent. The design's casing and accessible assembly is envisaged as a way of inviting users to also 'touch' and gain deeper practical insight into the object's construction, materiality and functionality.

Figure 9 Within the speculation, the 3D printing and the recycling of aluminium and bio-plastic electronic product parts are mainstream domesticated activities.

Figure 10 The prototype's modular design offers potential for personal customisation. An example of such is presented above – changes to the products' styling in the form of new coloured casings.

Figure 11 The Toaster For Life prototype's casing is a metaphor for 'transparency' of both form and function. It aims to entice users to open up the product and actively engage in sustainable practices including repair and upgrades. I took inspiration from these designs – Daniel Weil's 'Radio In A Bag' (left) and Freeplay's products (right).

5. Initial Conclusions

The *Toaster For Life* speculation seeks to challenge the ongoing legitimacy of centralised industrial product design in an era of increasing material scarcity, electronic waste and climate change. By envisioning an alternate strategy for the design, manufacture and consumption of an Internet connected device, the proposal aims to provoke audiences to also consider the sustainable potential of lesser-known practices and technologies which are central to today's decentralised technological sub-cultures. In doing so, *Toaster For Life*, like other design fictions, strives to "inspire an audience to think not only about what they do want for their future… but also what they do not want" (Auger, 2013, p.32). As a means to 'open up' a discursive space amongst audiences, my 'design fiction object' could also be described as a 'discursive product.' Here I have adapted Tharp & Tharp's term *discursive design*, a method they characterise as:

> "The creation of utilitarian objects/services/interactions whose primary purpose is to communicate ideas – artefacts embedded with discourse. These are tools for thinking; they raise awareness and perhaps understanding." (Tharp & Tharp, 2013, p.406).

Frayling separates design led research into three sub-categories – *into*, *through* and *for*. I see strong parallels between Tharp and Tharp's definition and Frayling's description of research *for* design (RfD):

> "Research… where the thinking is… *embodied in the artefact*, where the goal is not primarily communicable knowledge in the sense of the verbal communication, but in the sense of visual or iconic or imagistic communication." (Frayling, 1993, p.5).

However, as expressed earlier, I consider spime-based design fictions to not only be a lens for reflection for audiences *but also for the designers who seek to envision them*. In many ways, the design fiction process also corresponds with research *through* design (RtD). For me, the practicing of the design fiction was, like RtD, "a route to discovery [where] the synthetic nature of design allows for richer and more situated understandings than those produced through more analytic means" (Gaver, 2012, p.942). This indicates that the relationship between RfD and RtD is perhaps more fluid than Frayling's original delineation suggests.

While 'good' for the ensuing speculation, the use of 'new media' is a highly nuanced approach which can also have important implications for how design fictions are 'crafted.' Hales (2013, p.7) notes that "as media objects, design fictions are deeply implicated in the ecology of the media situation… they cannot be untangled from that milieu." As a self-described 'conventionally trained service to industry' product designer, I have found this 'entanglement' difficult to negotiate. Although the method removes the constraints of normative market-led product design, "constraints still exist… without them the design speculations could drift off into neverlands and dreamscapes" (Auger, 2013, p.34). Essentially, the crafting of the design fiction required the same level of attention to detail and expertise that would be needed if I were actually trying to design and produce the 'real' product. This created a 'blurred boundary' between normative product design practice and design fiction practice and was consequently a source of tension during the design process.

With its focus on narrative and the embodiment of ideas, the use of design fiction could begin to facilitate "alternative value systems for designers" (Voss et al, 2015, p.2). Chapman & Gant contend that:

> "Creation and consumption is both a natural and integral facet of human behaviour… problems arise when these deep motivations are expressed physically (e.g. objects, materials and new technologies), as opposed to metaphysically (e.g. stories, ideas and friendships)." (Chapman & Gant, 2007, p.6).

As an approach, design fiction negotiates the 'metaphysical' in that it is not concerned with the commercialisation of product designs but *the meaning of products and the futures they might bring.* Having said this, questions remain regard the rhetorical and ideological nature of 'design fiction objects.' As Gaver (2012, p.944) stresses, such artefacts embody "the designer's best judgement about how to address the particular configuration of issues in question." Like Sterling, I see spimes as a more preferable alternative to today's unsustainable models of production and consumption. The *Toaster For Life* is thus representative of my values and my ideology. However, I also understand that the notion of *what is preferable* varies from person to person. I therefore maintain that the *Toaster For Life* is a 'conversation starter', not an 'end product.' Whether or not others see spimes and sustainable futures in the same manner as myself is up to them, the *Toaster For Life* is a means for getting people to talk about such views.

6. Future Work

Deciding *where*, *when* and with *whom* such conversations take place is the next important step for this project. Voss et al (2015, p.3) highlight the lack of engagement with broader audiences across speculative design culture – "despite explicitly advocating [their] potential for 'helping people participate more actively'… many speculative design projects either operate as stand-alone spectacle, or… with those deemed to have 'expertise' – scientists and technologists, political scientists, economists." Thus, rather than being discussed solely within academia or presented in an art gallery setting like many critical design proposals, I see 'participatory' workshops as a more valuable forum to showcase the *Toaster For Life* design fiction. It is envisaged that this context would better facilitate discussions around peoples' perceptions of unsustainable technological product presents and potential sustainable spime-based futures.

Different audiences will likely focus on different themes. I intend to firstly organise a workshop to discuss the *Toaster For Life* proposal in relation to practical domestic issues including convenience, safety, efficiency, cost, time, quality, expertise, product warranty and aesthetics. Another workshop will be aimed at those working within the IoT field with the view to understanding how the fictional product is perceived in relation to present IoT devices. Both workshops would see *a discursive object being used to open up a discursive space*. As with RtD and design fiction, the aim of such endeavour is to generate insights for additional design praxis – further discursive objects – which, in turn, can be used to stimulate further debate. It is, in essence, an ongoing reflective process.

With the *Toaster For Life* representing only three of Stead's (2015) seven spime design criteria, I already see numerous opportunities for envisioning further worlds in which 'actually futuristic' spime products exist. The *Toaster For Life* principally focuses on the sustainability of a connected product's physical attributes. Could a spime object also be designed to sustainably accommodate changes to its digital characteristics such as software? Might the copious amounts of data that a spime generates be stored on, and, accessed via, the object itself? Or like today, would said data continue to disappear into the environmental uncertainty that is 'the cloud'? And how might spimes be framed in relation to the negative rhetoric presently associated with the IoT such as privacy, surveillance and the growing agency of connected products? In this light, the *Toaster For Life* can be seen as the first in an exploratory body of work which uses Sterling's concept as its lens. Looking further ahead, several spime orientated projects could well provide the foundation for a design manifesto for a sustainable Internet of Things.

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Making Service Design in a Digital Business

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Abstract: Digital businesses involve multiple stakeholders, each with their own distinct sets of values. In addition to the business value of the global digital ecosystem, a complex web of socio-cultural human values has emerged from digital development. In this research paper, this ecosystem is examined in a Finnish context, through business-led research and development consortia (Nee d for Speed, N4S). The aim of the paper is to present insights into a more socio-culturally sensitive research framework for a digital service development through three experiments using participatory and co-design tools: a stakeholder mapping tool, a value network mapping tool and a design game. The experiments follow the framework of three approaches to making the co-designs (i.e., probes, toolkits and prototyping) presented by Sanders and Stappers (2014). The theoretical framework is pragmatic, developing the process holistically through trial and error or, as a pragmatist would say, through the experience of disruption and crisis. (Kilpinen 2012).

Keywords: Service Design, Digital Economy, Participatory Tools, Pragmatism

1. Introduction

This research examines the digital ecosystem in a Finnish context through business-led research and development consortia (Need for Speed, N4S). During a two-year period, a service design approach was familiarised with the technologically led discipline and field of business. Starting to construct a common language, revealing and showing the complex interdependencies in digital service ecosystems and finally focusing on one genre in digital service design—the internal marketing and communications efforts of a large software-intensive company—were done to enable the familiarisation. Service design as a mindset and a multidisciplinary methodology has a new perspective to offer for digital ecosystem development, one that is at the intersection of technological systems development and socio-cultural process management. In this study, we have chosen a very practical and pragmatic approach to focusing on this kind of multidisciplinary digital service design.

The aim of this research is to present insights into a more socio-culturally sensitive research framework for digital service development, especially in the context of the Finnish software-intensive industry, through three exploratory cases using participatory and co-design tools: a stakeholder mapping tool, a value network mapping tool and a design game played with cards. The experiments follow the frameworks of three approaches to making co-designs (i.e. probes, toolkits and prototyping), as presented by Sanders and Stappers (2014), resulting in a supportive proposition. The probes (value network mapping) are designed *for* users' purposes in mind, the toolkits (stakeholder mapping) are designed *with* users' purposes in mind and the prototyping approach is adequate for both purposes (Sanders & Stappers, 2014).

The focus is neither to offer new methods into the service design methodology nor to highlight any particular method over another on the basis of their in-built socio-cultural sensitivity. Instead, the aim is to emphasise and fortify the social basis of existing design methods through the notions presented in pragmatist philosophy. The three experiments presented in this paper serve as descriptions of how community-led communicative action results in shared knowledge, a sensemaking truth approved by the participants of the situated practice (Jensen, 1991).

In the context of the Finnish software-intensive industry, customer insight is still heavily based on technical value propositions, such as the new product features offered to the customer. The service design approach, which aims to achieve end-user understanding, including a common ground of experience that the customer (the utterer) and the manufacturer (the interpreter) share, i.e. situational and contextual *commonage* according to Nöth (2011, p.180), is basically the same within any organisation where co-workers and colleagues are looking for collateral experiences to strengthen their communication.

The aim and focus of the N4S research consortia is to create shared knowledge (eco)systems instead of developing further the specialised silos of knowledge. The challenge is in the definition of knowledge, which, in our suggestion, is all about communication, communities and a common ground. A general definition of knowledge is quite static, hierarchical and related to the conception of truth. In relation to knowledge, this conception often refers to a one-way transfer of valid information, which thus neglects the discursive nature of such knowledge. A social pragmatist perspective of the concept of knowledge refers to an ongoing process of action that is essentially active meaning making in everyday situations (Kilpinen 2012).

A more comprehensive solution to the problem of the silo mentality within organisations starts from acknowledging the current practices in the separation of two types of knowledge: a) the technical comprehension of knowledge as expertise and typically accumulated in silos, and 2) common ground knowledge collectively experienced and shared. In fact, knowledge as human ideas and cognitive competencies is largely social inasmuch as experiences are felt to be collective (Bergman 2006). When the focus is on building structures and systems supporting also the discursive practices of knowledge creation, an organisation is more capable of becoming more transparent to its own staff and other stakeholders.

Service design tools, especially rough prototyping and mock-ups, serve as effective signs in "establishing a *commonage* of signification" (Nöth 2011, p.178). Prototyping, for example, is an approach that enables designers to focus intensively and holistically on touch points, on moments of the use of material and artefacts during the service design process, according to Sanders and Stappers (2014) and on the "alteration of habits", according to the pragmatist approach (Kilpinen 2012, p.62). In this sense the service design process is a constant procedure of change and meaning making and developed holistically through trial and error.

2. Methodology

The methodological and ontological perspective follows a service design definition taken from the pragmatist perspective of this paper. As a practical social process, service design calls for constantly reconstructing itself in a qualitative way. The empirical data gathered for service design research purposes is quite similar to case study research, action research and the principles of data triangulation, which all are sensitive to social and cultural representations of the on-going process. The new "things" and "changes" acquired during the cases were constantly changing the service design process itself: new challenges emerged, whereas the old ones were declared irrelevant for the development process, thus the new knowledge was acquired. This research approach has the ability to focus on actual practices on the spot; is reliable through the systematic transcription of data; is context-based; uses methods that reveal insights that are not quantifiable; actively involves researchers; constructs aims that are negotiated with the entire group; and creates context-dependent insights as an outcome. (Yin 2014; Denzin & Lincoln, 2003; Silverman, 1998; Greenwood & Levin, 2003)

In this paper, the participatory design tools and methods are applied inside a research consortia, as well as for developing more fluent internal communication channels inside larger companies. Participatory innovation gathers theories and methods from across different academic fields to describe and construct models of how people outside an organisation can contribute to its innovation (Buur, Ankenbrand, & Mitchell, 2013; Koskinen, Zimmerman, Binder, Redström, & Wensveen, 2011).

In addition to qualitative design research methodology, this research paper leans toward Peircean pragmatism, as illustrated by Kilpinen (2012). According to pragmatist process ontology, human activities during the service design process, such as end-user orientation and involvement, collaborative workshops and co-prototyping, serve not only as empirical data-gathering procedures from the classical research point of view, but also rise to the challenge of the limits of knowledge. Kilpinen (2012, p.47) defines social action as follows:

> "Action is to be taken as a process but not as a linear process, rather as one with a cyclical structure. This is because action is supposed to meet unforeseeable problems and hindrances that can stall its course. These problems, however, can usually be solved insofar as the acting subject makes use of her or his reflective resources."

The excerpt defines action in a way very similar to how action is used to treat and reflect design research, including the service design approach (Archer, 1995; Miettinen, 2009b). The recent effect that service design has had on the design research tradition is, for example, in bridging design to anthropology (Otto & Smith, 2013). Service design applies qualitative research approaches, such as anthropology, ethnography and social science methods (Sanders & Stappers, 2014). In addition, service design is implemented very often in instances of case study research, intervening action research, and in participatory action research – all descendants of the "[G]ood old Participatory Design," as Bjögvinsson, Ehn, and Hillgren (2012) have stated. Both design and anthropology refer to "a process character of human action" (Kilpinen, 2012, p.45).

In this research paper, the service design dimension is brought forth by bridging design research to social pragmatism. It has similar aims to anthropology, which is to involve everyday human activities in the design process, but in a way that emphasises the social aspects of the process character of action. This notion to action as a social process contributes to the prevalent perceptions of design thinking as an individual and inner process of a designer (Cross, 2006), but at the same time it pilots the theory of design thinking towards the fields of user-centred design, participatory design, co-design, service design and social design (Miettinen & Valtonen, 2012; Sanders & Stappers, 2014; Sangiorgi & Prendiville, 2014).

3. Making in Digital Services

The research frame in this paper is part of a larger ensemble of service design, development and research projects designed and implemented at the University of Lapland, Faculty of Art and Design since 2009. The programmatic nature of this research is constructive (Koskinen et al, 2011), and the research has progressed piece-by-piece, becoming a culturally sensitive approach to service design. The service design team at the University of Lapland has systematically collected qualitative research data from projects utilising a SINCO (Service Innovation Corner) laboratory, where service design has been strongly integrated into business development through observations, videotapes, questionnaires, and other documents (e.g., meeting notes, invitations and workshop outcomes), and always in collaboration with the real companies (Rontti, Miettinen, Kuure & Lindström, 2012). Since the beginning of this programmatic research ensemble, which began in 2009, the general research frame has mainly followed a qualitative design approach, including multiple case studies and iterative action research (Yin, 2014; Greenwood & Levin, 2003). Company case studies aim at service design concepts, and are carried out through service prototyping and other participatory and collaborative workshops with the company representatives involved.

The results of previous research projects also served as the basis for the research implemented in the N4S consortia presented in this paper.

Recent research interest at the University of Lapland is directed towards digital service design research and development, together with the major software intensive companies in Finland. The built-in aim has been the development of digital service design tools and methods as an iterative process in a four-year time frame in the N4S research programme, starting with problem-based and end-user-oriented service design briefs (2014) forging ahead with in-depth service design thinking among partner companies (through 2017). Throughout the program, service design tools and methods will be developed for the digital economy, and the partner companies are directed toward an in-depth understanding of customer-oriented, explorative and real-time value creation on a case-by-case basis (Miettinen, Rytilahti, Vuontisjärvi, Kuure & Rontti, 2014).

3.1 Probes in Mapping the Value-Network of Digital Ecosystem

A metaphoric example of the best work practices used in the software-intensive digital industry is to copy commando procedures: Successful companies parachute their design teams into the emptiness, leaving them to survive in completely new business and design contexts. To survive, the commandos have a set of basic tools to use in their new environment. In this paper, these tools are service design and design tools such as prototyping, probes and stakeholder mapping (Stickdorn & Schneider, 2011). These tools are used to support interaction and communication between people such as humanists, scientists, engineers, business people and ordinary end-users who do not share experts' terminology and language. But what are those tools, and how is the toolbox assembled for the expedition to an extended digital ecosystem?

In Finland, the digital technology, software engineering and expertise are excellent, but the assimilation of a more user-centred approach to developing digital products and services is comparatively slight. The development processes are technology-led, and the relevance of the end-user and research has developed from decades of empirical research conducted on information systems (IS), human-computer interaction (HCI) and design research. The common aim of these design science fields has been to use the latest technological solutions to design, redesign and improve an organisation's functioning (Kuutti, 2007). In the early 21st century, this is still a problem, and large companies and corporations have started to look for added value from human-centred design and service design perspectives. Service design methods offer ways of analysing end-users' and customers' motivations and emotions and tools for constructing internal organisational processes in collaboration. A main finding is that service design serves as a platform on which the company's values, customers' needs and motivating emotions meet (Miettinen & Valtonen, 2012; Stickdorn & Schneider, 2011; Stickdorn & Schneider, 2011). This visualized mapping is based on studying end-users' and customers' values and value networks (Heinemann, Mitchell, & Buur, 2009).

A participatory design tool, a silver set, a collection of silver-coloured bric-a-brac, developed by Heinemann, Landgrebe and Mitchell (according to Heinemann, Mitchell, & Buur, 2009), was tested as a tangible and collective mapping tool among the N4S consortia partners (Figure 1). The workshop and the new tools experiment had three aims. The first was to get to know each other in smaller groups, since about 150 people participate in the trimonthly consortia meetings. The second aim was to familiarise company representatives with an actual end-user of their products and services. In this workshop, the real end-user was an 80-year-old woman, “Granny”, who was presented to the group by replaying an edited video profile of her. In the video profile, she talked about her everyday life, personal contacts, values and challenges. The third aim, and the final result of the workshop, was a visual and tangible network of values from the end-user’s point of view, a perspective not very familiar to the company partners of the consortia.

Figure 1 Tangible value network mapping with the ‘silver set’ tool. Research and company partners of the Need for Speed (N4S) research programme think out loud about how digital services are experienced by the potential end-user.

The “silver set” experiment was used so the people invited to the workshop could come up with the need to build something especially for the use of the whole consortia, a tool to which everyone can contribute and a tool for constructing a common language for the collaboration.

> “Who is that ‘Granny’?” asks the moderator of the workshop after replaying the video profile. She continues, “She is a real person.”
>
> The three groups start discussing “Granny.” They stand still, their hands in their pockets or with their hands on their hips.
>
> “What are her values in her everyday life? Who are her family members, friends and who belongs to her circle of acquaintances?” asks the moderator. After a while, she

> asks the groups to move on to fiddling with the pieces of silver bric-a-brac on the table in order to get familiar with the objects:
>
> "What are the bits of silver bric-a-brac like? What are the features of those things? What do they feel like?" she asks.
>
> The group members end up picking one or two items from the table. They start to describe the features of those things. Everyone has something to say about the piece she or he has chosen. People start to "think with their hands," as one of the participants stated. [Excerpt from a video analysis]

After participants began "thinking with their hands", the groups discussed the values that the end-user, "Granny", appreciates. With or without the silver pieces, the participants shared their ideas about her values and value networks.

The next phase called for thinking about these values from the value proposition, or from the business point of view: How can your company, whose business is in software-intensive digital technology, serve Granny and help her sustain her value network?

The first notion of this kind of tangible mapping of values was how the values that Granny mentioned were not the values she was granted. There were many reasons for this: The value offerings by the companies did not match older people's values; or the values that Granny appreciated are dissimilar to the values of the other stakeholders involved in the value network (i.e., family, relatives or service workers at the retirement facility). As a result, the participants emphasised a service broker whose assignment was to create a digital service offering that Granny and others involved in her value network would value.

In the final discussion, three value network maps, in which the core value propositions for the digital business were freedom, security and support, were presented. For example, the silver and metal bric-a-brac were taken as more serious and professional tools for use than items made of Plasticine, paper tubes, wooden building blocks or disposable paper and plastic ware (Buur et al, 2013). The participants felt it was easier to collaborate with people from different fields of expertise. An example of the most frequently used "blocks" or things were the chains used to illustrate the connections between different factors and values and the distances between them. In general, the notions concerning the task and tools were positive, and the three final presentations of value networks provided a general view at the latest shared comprehension of the real user-value.

3.2 Toolkits in Designing with the Stakeholders

The reputation of a solid, secure Finnish software technology expertise is being challenged by global stakeholders proposing open-source and open-data approaches. The preliminary data collected and analysed for the service design cases through teleconferences, focus group workshops, stakeholder maps and participatory design methods have yielded a more defined research framework. The structure of the research frame from the on-going company cases is relevant, since the approach for a longitudinal, iterative case study on the Finnish digital ecosystem requires a multidimensional perspective from the business point of view. This multidimensional perspective reaches all the way to the end-users of the digital products and services. The research framework also caters to socio-cultural perspectives related to Finnish digital business development as a central focus of service design research.

The focus group method is a tool for organising a group discussion under a predefined issue or theme. In the cases presented in this paper, the focus is defined through the actual company cases, the design briefs from the service design and the research point of view. One general advantage of these small-scale and company-specific case studies is the opportunity to interact and communicate with each other in consensus, and to construct a common language between the consortia partners from various fields of expertise.

The first stage result of a company case is a stakeholder map constructed by analysing the data collected in the focus groups (Figure 2). The internal processes of the company and the company's relationships with external stakeholders was made visible through this visualisation.

Figure 2 A stakeholder map visualised based on a focus group analysis (H.-R. Vuontisjärvi).

"One really smart visual form can change everything," noted a focus group member, when he saw the first layout of a simplified stakeholder map of the organisation. Specifically, large corporations in the software-intensive industry are fulfilling and communicating their systematic and efficient work methods by making technical and other details more visible, instead of decreasing the details and simplifying the ones left visible. A simplified visualisation or a map of a company's stakeholders represents an efficient tool for increasing the transparency of the organisational processes inside the company and outside for business customers and other stakeholders.

Service design tools are used for design thinking (Miettinen, 2009a; Miettinen & Valtonen, 2012; Sangiorgi, 2012). These tools support designers' methods of thinking or design knowledge as a research locus originating from three sources: people, processes and products (Cross, 2006). In addition, the designers' methods of knowing, or the mode of designers' thinking, is solution-focused problem solving, since the designers' main tasks are solving and tackling "ill-defined" problems. In addition, a key skill in design thinking is the ability to use ‘codes’ that translate abstract requirements into concrete objects. This requires metaphorical, iconic, indicative, and symbolic skills of reading and writing, (i.e., visualising in “object languages”) (Cross, 2006).

3.3 Prototyping Internal Communication

During the summer 2015, a service design experiment aimed at experience prototyping was launched together with a large software intensive company as part of the N4S consortia. The goals for the collaboration were organisation and business oriented: to facilitate and implement a service design case to firm up the image of the knowhow, processes and business potential situated in teams inside the corporation. One team (made up of approximately 13 people) inside the company enrolled as a focus group for this agile service design case after the first kick-off meeting. The service design team of the University of Lapland constructed a service design brief, and the agile case, in collaboration with the focus team, started. From the research perspective, the aim was to collect data on the lean and agile development processes in digital business, especially from the service design point of view.

Coughlan, Fulton Suri and Canales (2007, p.133) are convinced of the value of prototyping as an organisational development and change method: “Not only does prototyping change the conversation, it changes behavior”, they say. In prototyping, the time and energy otherwise spent discussing and planning future visions verbally with abstract meanings is now employed in creative, collaborative and constructive activities. Prototypes give people permission to act differently (Coughlan et al, 2007). According to Bruce and Wyman (1998, 169), the role of the prototype is to be “an actual implementation of the critical parts of change”, and this also seems to apply to changing organisations by design (Coughlan et al, 2007).

In summary, the main results of the agile case are applicable to business, organisation and service development, since the service design prototype was actually a concept developed the furthest ever by the service design team at the University of Lapland. In addition, the prerequisites for a successful case were the commitment to the case by the focus team. This was a ‘thank you’ to the prototyping approach, which gave the participants a comfortable feeling when participating to the case. The knowledge the company’s team possessed was enough for participation, and there was no need for a “prolonged analysis of existing or historical practices” or managing the company’s strategy or other definitions of policy (Coughlan et al, 2007, p.132). Also, the face-to-face collaboration during the multiday workshops in the team’s open-plan office was a factor that supported the faster progress of the service design case.

A straight result after the first multiday workshop with the focus team was a map or visualisation (i.e., blueprint of the communication channels and procedures used by the company team in relation to their customers inside and outside the company) (Figure 3). The blueprint was the first act ever accomplished inside the team as it tried to build an internal communication progress into a concrete format of any kind.

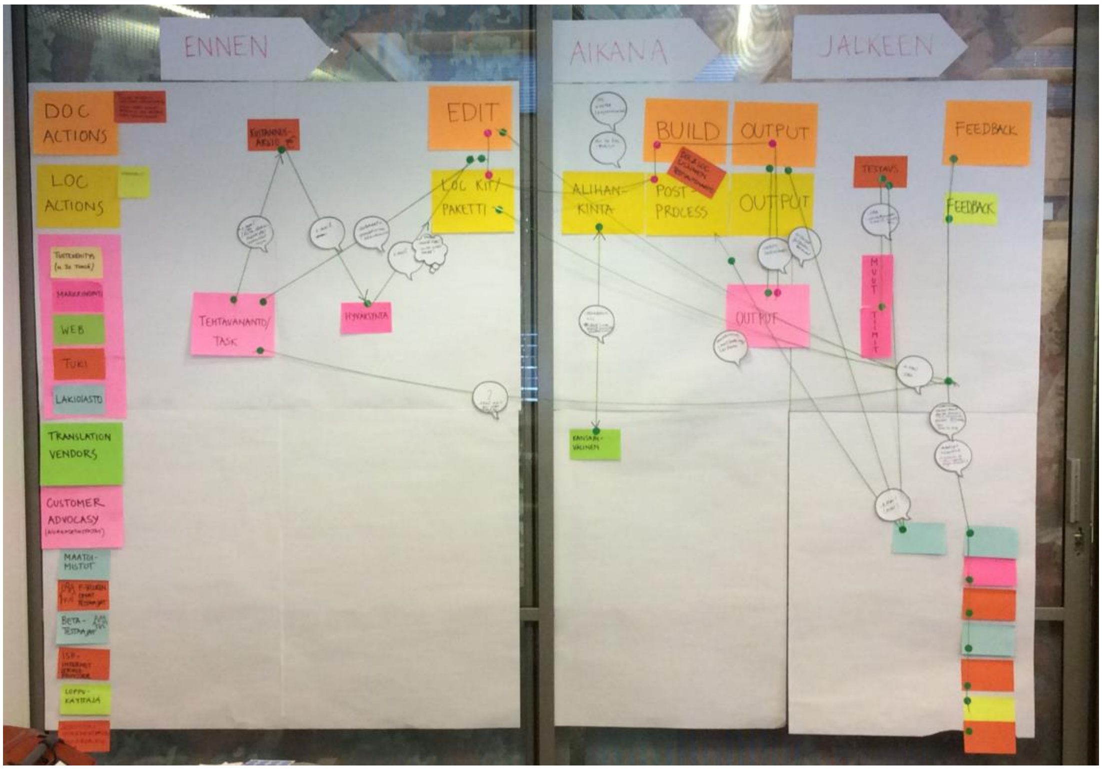

Figure 3 First blueprint constructed in collaboration with the focus team.

Five other prototypes for internal communication were produced during the same service design case: a service catalogue, a card game, a service tool proto, a service guideline and a marketing campaign. A common benefit of all the prototypes constructed was quite basic and necessary in every communication, yet still clearly less obvious inside the company: The knowledge possessed by the team and the objectives of the work performed by the team was now transparent and easily available to the other teams and units inside the company.

The card game was an interesting, easy and motivating prototype from the company's point of view (Figure 4), though designing its content and rules was not an easy task to pack up, and it demanded three iteration cycles of testing and development in collaboration with the focus team. The first sprint of the game prototype was designed to be as real as possible, aiming to reproduce communication procedures and customership actions. During the subsequent iterations, the game was simplified piece-by-piece by using the tangible elements to guide the proceeding of the play as much as possible. The card game was designed to improve internal communications and to demonstrate internal services. In addition to the aim of introducing the actions and services offered by the team for the internal customers of the company, the other aspect was to present more clearly how services are delivered.

Figure 4 A prototype of a card game for the company's internal communication.

As opposite to a common conceptualisation of the neatly engineered service systems, this paper presents a slightly "messier view of services" (Sangiorgi & Prendiville, 2014, p.69). The card game is a prototype constructed by the service design mindset, illustrating that service design ought to be viewed even "less designed and more assembled from fragments of practices, institutions, life-styles and networks" than before, a kind of a conceptualisation of services that is consistent with the anthropological perspective of services as part of the human historical and localised conditions, or organisationally historical conditions, in this case (Blomberg & Darrah, 2014; Sangiorgi & Prendiville, 2014).

The results of this experimental case are parallel with the view of Coughlan, Fulton Suri and Canales (2007), suggesting that prototyping is a powerful means to "facilitate organizational development and change". Especially, the value of prototyping as an action of "building to think" seemed to start to contribute not just to the process development of the team, but also to the more general thinking from the organisation's point of view (Coughlan, Fulton Suri & Canales, 2007). Also, as a focal result of this case, we noticed the growth in motivation and commitment when being able to participate in a process whose progression is made so visible and tangible. This is the pragmatist perspective to social innovation. Social relations in a team, unit or more generally at the organisational level still emerge through social action, not just through social being (Kilpinen, 2012, 63; Kurvinen, 2007).

4. Conclusion

Service design for and with Finnish digital businesses starts with the construction – or designing – of a common understanding of the digital phenomena, including equally the technological, economic and socio-cultural perspectives to digital development. At the moment, the digital business is developed the technologically led, forging close ties between technology and systems development whereas collaborative, motivational and creative small-scale processes inside companies are not very well plugged into the corporate level management. The inconsistency in the scalability between the large-scale and the small-scale processes and innovations lies in the direction of the processes (from technology to service orientation), as with the character of the innovations developed, or undeveloped, the main emphasis is still on technical innovations at the expense of social innovation.

The methodology used in this research is coming from the service design, design anthropology and constructive design research, with an ontological twist toward pragmatism. The exploratory cases have constructive aims, and as a type of an action research approach these aims are enacted through company-specific case studies. Therefore, we have chosen a very practical and pragmatic approach. Three exploratory case studies are presented, aiming to evoke a discussion and to create a more common understanding of the digital business ecosystem in Finland. As a preliminary result, a preliminary framework for more user-oriented Finnish digital business research and development, in which the discussion of the values offered to business development through participatory design tools, is presented.

According to the pragmatist perspective of the process character and design-based approach to organisational change, we propose that large technology and software intensive companies take action inside their organisations, and especially in the field of down-top social innovation. This does not mean they should make a move towards technology, but rather that they should make a move towards internal (and external) logics and tools of social actions. Maybe the teleconferences, intranets or e-mails are just part of a larger system of social interaction still undermanaged in the large companies.

The question of further research is what we have learned about the logics of processes in a small-scale (i.e. at the team and community level), and how these findings are applicable to large scale (i.e. at the corporate level). How can service design help various types of processes and their realisers to keep pace with the development (i.e. to give tools to notice and address the possibility “for new grooves” in existing processes)? However, to give a reminder of the pragmatist perspective to process character of action, the question is also how service design is able to give tools and mindsets to treat the process as an integral whole, not only as separate actions or problems to be solved. Digital service design is taking place at the intersection of technologically led development and customer-focused service thinking (Vargo & Lusch, 2008). When the software systems’ designs and the human-centred orientation of service design have proper instruments to merge the technical and social features into a common and a transparent whole, though a much more simplified conception of a serviceable process, the results are to be inevitably supportive of new digital economic growth. This is also what ‘agile’ and ‘lean’ could mean in a social pragmatist sense: there are also ‘little’, incremental moves in a joint process of material (technical) and social actions.

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Ad Hoc Pairings: Semantic Relationships and Mobile Devices

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Abstract: As the digital world continues to become more mobile and wireless, a new challenge has arisen in this always connected landscape. That challenge has been created by the very thing that has helped to enable this nomadic experience – the loss of wires has resulted in a loss of what was once visually mapped connections between two or more digital objects which helped to semantically defined the relationship between ad hoc devices as well as user and devices. Current applications require the use of screen-based (explicit) interfaces to manage these connections but this research explores opportunities to leverage more implicit and tangible methods to creating these connections. This research and resulting user study (N=12) explored the use of gestures between primitive forms as a means of encoding paired relationships. The analysis of the resulting 108 patterns generated helped to isolate pairing attributes and an encoding protocol that could inform current and future tangible connections between digital devices.

Keywords: industrial design; interaction design; mobile computing, ad hoc

1. Introduction

As many have predicted, digital objects and their future incarnations continue to weave themselves into the everyday world (Weiser, 1991). This growing computational world is not only filled with digital devices and their resulting interfaces but also the networks that connect them. Connectivity is as much about ubiquitous networks as it is about the objects that inhabit them. The particular increase in wireless networks have allowed for devices and their users to become free from the burden of wired connections. As a result, wireless networks have been implemented to address a range of issues that wired connections could not (Aarts & Marzano, 2003) as well as breaking down the barrier of managing various cord nomenclature or unique port connections between different device manufactures (Miller, 2001). In many ways the increase in wireless connections has been both a blessing and a curse. Wires for all their challenges and nomenclature issues also provided visually 'mapped' (Norman, 1988) connections that helped users to define the 'relationship' between two or more devices. Design's response to this problem has been to push the relationship management of connected wireless devices to explicit screen-based interfaces. As a conceptual model (Krippendorff, The Semantic Turn: A New Foundation for Design, 2006) of connected relationship, this approach can be particularly troublesome when it comes to ad hoc devices that operate within an infrastructureless network. In this ad hoc future, users will have the ability to connect any number of ubiquitous devices in order to share data, control operations, or expand their personal relationships with other users just to name a few (Elixmann, 2003). These personal area networks (PAN) like Bluetooth and near-field aim to promote a decentralized approach to computing with a diverse set of connection possibilities (Hansmann, et al., 2003). Along with this decentralization has come a variety of use cases that will need to be addressed as they relate to the Internet of Things (IoT) (van Kranenburg, et al., 2011), the least of which is the relationship management and instrumental engagement (Greenfield, 2006) between many of these connected objects. Connecting, controlling, and coordinating escalating environments of devices will enable users to expand their personal relationship and share data as well as control everyday objects in new and exciting ways (Elixmann, 2003). To that end, screen-based interfaces will not be the only means to coordinate these interactions and design has the opportunity to utilize the physical object itself to guide these connections. This approach may come to contribute to a type of 'ubicomp grammar' or ubicomp user interface (UUI) (Quigley, 2010) to better enable the integration of computation in to everyday objects and leverage their tangible qualities.

This research and resulting user study (N=12) explored the use of gestures and pattern making between primitive forms as a means of encoding paired relationships. The analysis of the resulting 108 patterns generated helped to isolate pairing attributes an encoding protocol that could inform current and future implicit tangible interfaces between digital devices.

2. Semantics and spatial organization

Creating connections and relationships between digital devices was once the domain of the plugs and the wires. As that continues to shift to more ubiquitous forms of wireless connection, design will need to develop a new semantic approach for what it means to be connected. At the end of the day, the goal for most designers and perhaps design as a discipline is to develop 'meaning'. In this context, the word 'meaning' is the ability to convey signs (Boradkar, 2010) of a given system through pattern and structure (Kazmierczak, 2003) so as to allow for the user to interact with that system in a productive way. Design has developed some of its own approaches to the systematic analysis and construction of meaning. In the particular practice of product design, the approach to semiotics is often referred to as 'product semantics' (Krippendorff & Butter, Exploring the Symoblic Quilities of Form, 1984) or the study of the symbolic qualities of artefacts and how these qualities inspire people to interact with them. This point of view is primarily grounded in the perceptual aspects (sense making) that an artefact may illicit through the design and construction of interface and form. This school of thought has led to a series of guiding principles or good practices when endeavouring to communicate the utility of an object as well as how to directly interact with that object. In the past, the naturalness of form (Krippendorff, The Semantic Turn: A New Foundation for Design, 2006) in artificial objects was driven by the manufacturing process utilized to create the artefact as well as the inherent functionality (mechanical workings, etc.) of the object which could aid users in better communication and interaction. With the growing absence of these qualities informing computational devices, a certain level of functional ambiguity has arisen (Kawanari, 2011). In an effort to combat the loss of these qualities, design must attempt to encode a sense of operation, relationship, and status into machines so as to be decoded by users. Much of the discourse, practice, and theory surrounding product semantics as well as the application of its tenants (affordance, constraint, mapping, etc.) (Gibson, 1979) (Norman, 1988) have done little to directly prescribe for the dynamic and time based signals that digital products are capable of producing.

The goal of this research was to determine new tangible ways in which users can generate paired wireless relationships between two Bluetooth devices utilizing the formal attributes of the shape and its relationship to other shapes or objects. In an effort to gain knowledge and create a framework for future design, this study sought to understand and ultimately develop a protocol for encoding spatial relationships between two or more digital objects. This study is grounded in both psychological theory coupled with the resulting findings.

The challenge of understanding relationships based on visual stimuli is a challenge of visual organization. More specifically, the organization that is likely given a certain set of objects (devices) and a desired understanding based on that organization. The goal was to try to isolate the various mechanisms (spatial encoders) that one might use to create a paired relationship between two Bluetooth devices. Although the resulting experimental study may emulate certain elements of a traditional Gestalt study, it differs in one particular perspective. Although the use of basic forms (black) was applied to a particular ground space (white), it was the participants that were constructing these patterns and relationships based on the three stimuli words (disengaged, engaged, connected). It was a top down process of 'encoding' spatial relationships versus a 'decoding' or interpretation of visual information. In many psychological studies related to perception the focus is that of 'decoding' the visual stimuli. The distinction is that the study outlined in this paper was a cognitive exercise as it relates to spatial organization. In doing so it was accounting for the fact that a user engaged in understanding his or her wireless environment and the relationships that lie within it, is not only concerned with identifying (decoding) the existing relationships (the speakers are paired to the TV) but also in creating (encoding) or directing new relationships. So isolating the mechanics of this type of relationship construction was the focus of that study. In combining what is known about perceptual organization with what was discovered about rectilinear pattern generation (primary work) a protocol was developed for how individuals devise relationships from visual patterns.

3. Description of research methodology and results

3.1 Basic study characteristics

This study's aim was to isolate how people utilize spatial organization of physical forms to create meaning. More specifically the study sought to identify patterns of spatial organization that could be used to further inform a tangible or gesture-based approach to creating Bluetooth pairings between two digital objects. Leveraging the physical form of the object could lead to an implicit interaction framework that would rely less on the explicit screen-based interfaces of mobile devices and more on the proximity and alignment of the physical form of the devices. To that end, this study focused on identifying the common patterns that are encoded by individuals when prompted to create a relationship between two specified forms. These forms were primitive shapes like circles, squares, and rectangles so as to not directly represent a known digital device. In doing so, the study aimed to eliminate as many independent factors as possible. The second experimental tool used in this study was a set of three words as stimuli. The words were; 'disengaged', 'engaged', and 'connected'. These words were representative of a relationship state to signify connecting two or more digital devices together via Bluetooth connection. Further review of the data collected as well as its implications can be found in the discussion section of the paper.

Sample Characteristics:

- Sample size: 12
- Gender: 50/50 (male/female)
- Mean age: 29 yrs.

Study set-up:

- One on one (researcher/participant), 30 minute personal interviews in isolated environment (Figure 1).

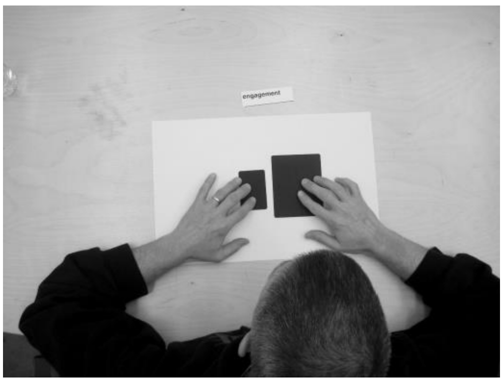

Figure 1. Study setup

3.2 Procedure and experimental tools

Participants were asked to arrange a given set of black forms (figure 2) on a white bounded space (279 x 432mm paper) based on a stimuli word. The forms could touch but not overlap or be placed outside of the bounded space (figure 3). For each form combination (treatment), one of three word stimuli was used at random and the given participant then had to position the individual forms so as to encode or create a representation of the word. This was repeated until all three word stimuli had a resulting pattern generated by the participant at which point a new set of forms was utilized and the word stimuli were administered again. Photographs were taken of each of the patterns generated so that they could be analysed later to identify similarities. There was a total number of 3 treatments or sets and 9 combinations (figure 4) that an individual participant could generate which resulted in a collection of 108 form combinations or patterns. The main focus of this exercise was to isolate the patterns from paired combinations between the small circles, squares, and rectangles. The goal in isolating these patterns was to determine how people utilize spatial characteristics to create visual pairings or relationships based on a set of actions (stimuli words). These actions were to evoke visual meaning for the potential different states one might desire in a Bluetooth pairing between two digital devices. The data and resulting insights from this study could then be utilized as a foundation for developing a tangible user interface approach to pairing protocols or gestures.

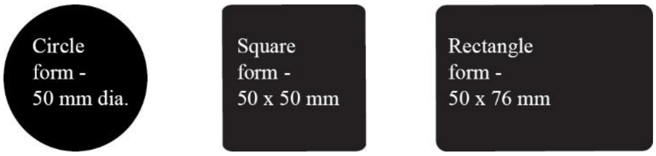

Figure 2. Form samples

Form combinations resulting in patterns (3 treatments / sets, 9 total combinations):

17) Two circles (same scale)
18) Two squares (same scale)
19) Two rectangles (same scale)

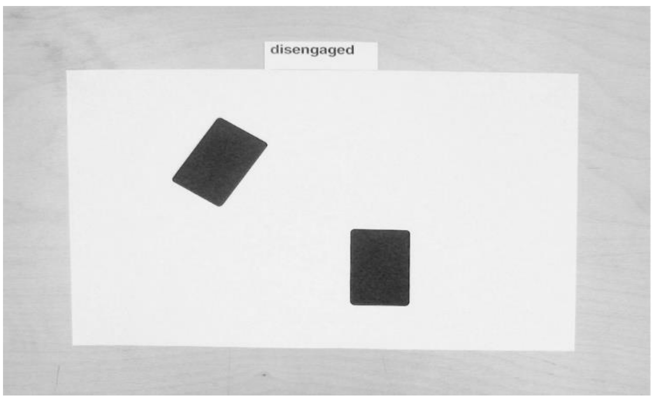

Figure 3. Sample of participant encoded form patterns (rectangle)

Word stimuli:

20) Disengaged
21) Engaged
22) Connected

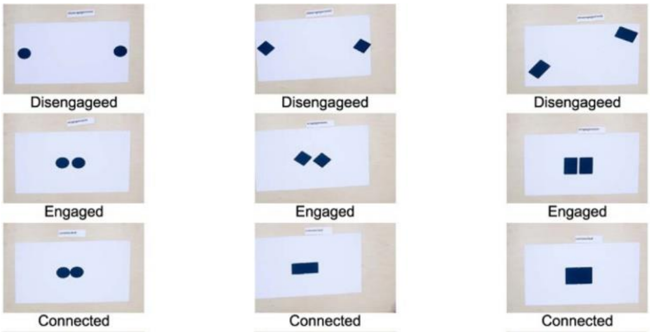

Figure 4. Sample data collection from one participant (3 treatments)

3.3 Results: Circular Forms

After completing the study and collecting all of the photographed data, analysis was first performed on the circular forms to identify common patterns of association based on word stimuli (disengaged, engaged, and connected). The circular forms allowed for a reduced number of variables to be examined. Circles on a flat plane do not have an 'orientation' component which allowed for 'proximity' to be the primary method for pattern differentiation.

Coding:

After common patterns were identified, a code was assigned to each pattern. The coded data was then applied to a frequency of distribution graph so as to highlight the main forms that were used to describe each action; engaged, disengaged, and connected. The resulting outcomes of the coded patterns for circular forms are depicted in figure 5, 6, and 7. Coding is as follows:

PD# = pattern, disengaged, number

PE# = pattern, engaged, number

PC# = pattern, connected, number

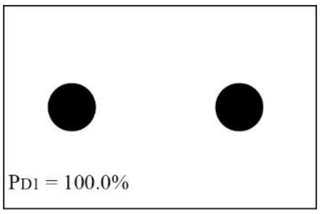

Figure 5. 'Disengaged' pattern results – circle forms

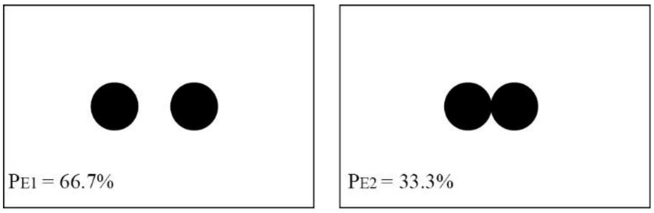

Figure 6. 'Engaged' pattern results – circle forms

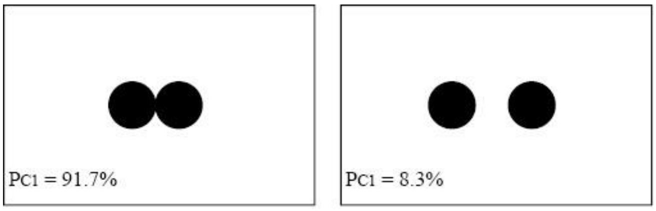

Figure 7. 'Connected' pattern results – circle forms

Circular forms – analysis:

The patterns generated by the participants served to isolate various attributes or mechanics that were used by individuals in responses to three stimuli; 1. Disengaged, 2. Engaged, and 3. Connected. These stimuli combined with the task of creating a patterned representation with the given shapes (circles, squares, and rectangles) provided constraining properties. Based on the collected data for the circular forms, the most dominate patterns that participants generated are shown in figure 8. In the case of the two circles and three word stimuli, the only way that participants could encode unique patterns for each word was to adjust the distance or 'proximity' between the forms as circles by their nature due not allow for alignment variation. Through this isolation and pattern analysis, participants responses showed a strong tendency to place circles at great distances from one another to represent disengagement and place the same circles either touching or at a reduced distance from each other to represent connected. As one pattern is not only an interpretation of the word stimuli (disengaged) but also relative to the other words that followed it (engaged, connected). The patterns have more meaning when compared to each other to denote a coded state. The relationships of the states through 'proximity' then becomes the primary mechanic (attribute) that participants used to translate the stimuli into structural forms. In isolation, proximity attributes can be interpreted as the following:

1. Disengaged = great distance of proximity
2. Engaged = reduce distance of proximity (from disengaged state)
3. Connected = further reduction of proximity / distance (from engaged state) to allow for touching surfaces

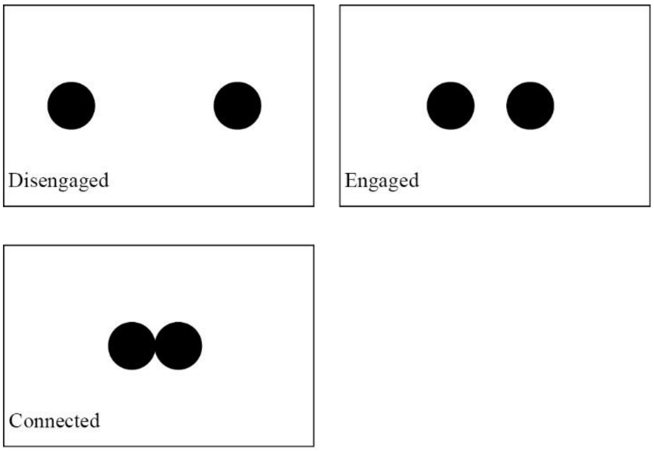

Figure 8. Most dominate patterns – circle forms

3.4 Results: Square Forms

The patterns generated by participants based on the two square forms and word stimuli were recorded and evaluated in the same manner as the circular forms. The resulting outcomes of the coded patterns for square forms are depicted in figure 9, 10, and 11. Coding used the same nomenclature as the circular form coding:

PD# = pattern, disengaged, number

PE# = pattern, engaged, number

PC# = pattern, connected, number

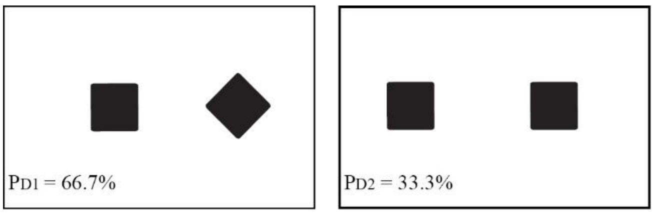

Figure 9. 'Disengaged' pattern results – square forms

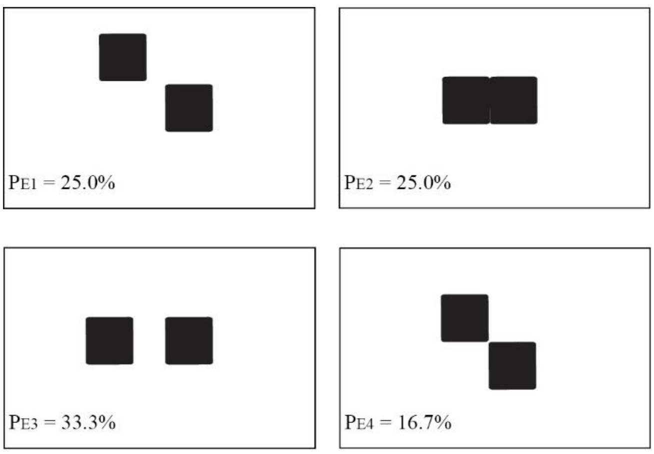

Figure 10. 'Engaged' pattern results – square forms

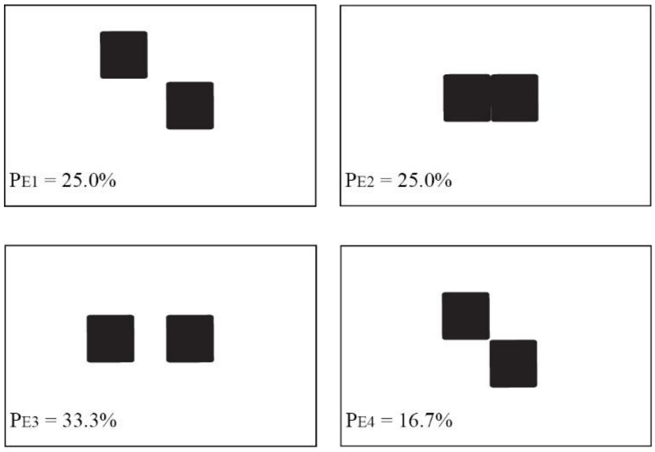

Figure 11. 'Connected' pattern results – square forms

Square forms – analysis:

The same exercise was repeated for two squares which introduced the possibility of alignment (orientation) as a mechanic that individuals could utilize in spatial encoding. After reviewing the square form combinations, there were no overly dominate patterns that were identified aside from the 'disengaged' treatment. As proximity and orientation could be utilized by participants in both the square forms and rectangular forms, it became more informative to evaluate the rectangular pattern data to identify potential insights.

3.5 Results: Rectangular Forms

The patterns generated by participants based on the two rectangular forms and word stimuli were recorded and evaluated in the same manner as the circular and square forms. The resulting outcomes of the coded patterns for square forms are depicted in figure 12, 13, and 14. Coding used the same nomenclature as the circular and square form coding:

PD# = pattern, disengaged, number

PE# = pattern, engaged, number

PC# = pattern, connected, number

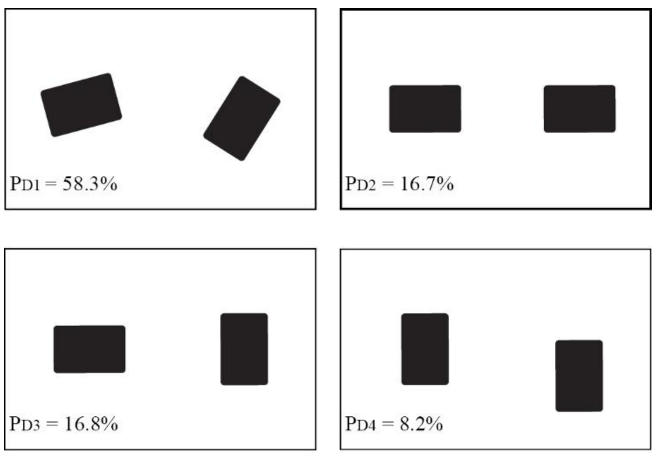

Figure 12. 'Disengaged' pattern results – rectangular forms

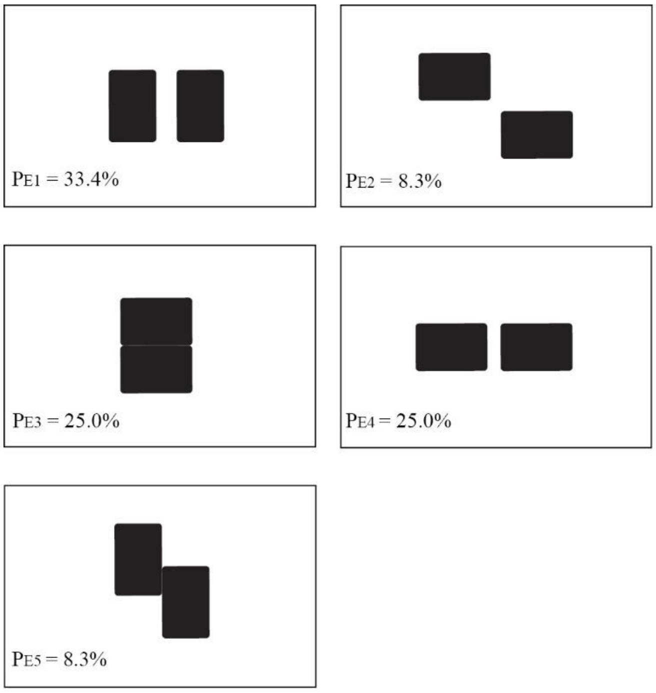

Figure 13. 'Engaged' pattern results – rectangular forms

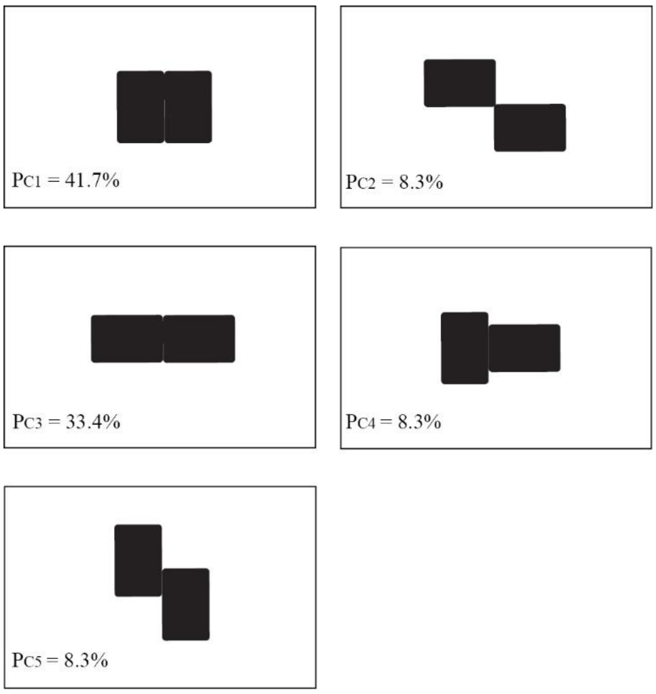

Figure 14. 'Connected' pattern results – rectangular forms

Rectangular forms – analysis:

Analysis was then performed on the rectangular forms to identify common patterns of association based on word stimuli (disengaged, engaged, and connected). With the rectangular forms there were two potential mechanics for participants to use in the generation process; 1. Proximity and 2. Orientation. As the circular forms helped to define a protocol for proximity, the aim was to use the rectangular forms to gain insight on how orientation is used to denote various states. The most common patterns produced by participants are depicted in figure 15.

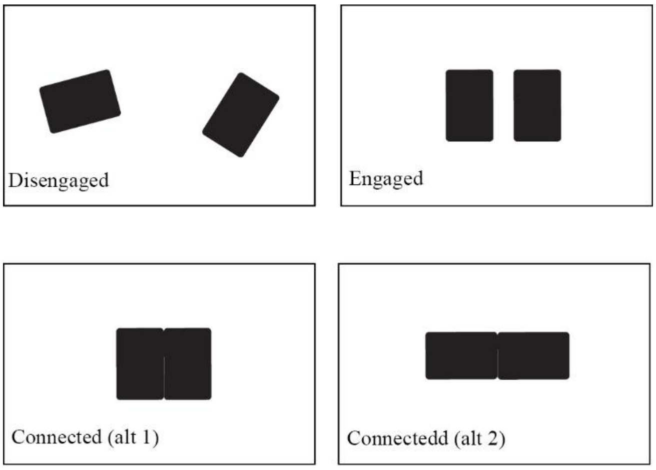

Figure 15. Most dominate patterns – rectangular forms

All forms – analysis:

Although there was a great variety in the patterns that participants produced based on any given stimuli (Table 1), there were similarities among the characteristics of a set of patterns. If one reviews the patterns generated for "disengaged", it is apparent that proximity / distance is the major underlying mechanic that was used by participants to denote that state. Additionally, 58% of respondents utilized misalignment of edges as an orientation characteristic for "disengaged" while the other 42% used some form of alignment. Again, in the "engaged" set of form patterns there is a consistent use of proximity (reduced from disengaged). This reduction of distance between the two forms resulted in closure and in some cases touching surfaces. Orientation varied with respect to any one particular pattern but the consistent element between them all was the alignment of edges which 100% of the respondents produced. "Connected" showed continued utilization of proximity, with all respondents producing touching forms and reduction of distance from "engaged" state to "connected" state. Additionally, all forms showed patterns of aligned edges with respect to their orientation. The majority of participants (75%), produced aligned patterns of shared similar edges.

Table 1 Responses to Form Generation

		Circular Forms		Square Forms		Rectangular Forms	
		Response	% of total	Response	% of total	Response	% of total
Disengaged	P_{D1}	12	100	8	66.7	7	58.3
	P_{D2}			4	33.3	2	16.7
	P_{D3}					2	16.7
	P_{D4}					1	8.3
Engaged	P_{E1}	8	66.7	3	25	4	33.4
	P_{E2}	4	33.3	3	25	1	8.3
	P_{E3}			4	33.3	3	25
	P_{E4}			2	16.7	3	25
	P_{E5}					1	8.3
Connected	P_{C1}	11	91.7	5	41.7	5	41.7
	P_{C2}	1	8.3	6	50	1	8.3
	P_{C3}			1	8.3	4	33.4
	P_{C4}					1	8.3
	P_{C5}					1	8.3

Based on the collected data and examined patterns, orientation protocols can be interpreted as the following:

1. Disengaged = misalignment of edges and distance
2. Engaged = alignment of edges and reduced distance (from disengaged state)
3. Connected = alignment of similar edges and further reduction of proximity / distance (from engaged state) to allow for touching surfaces

4. Discussion and Expanded Theoretical Background

4.1 Summary of form generations

The patterns generated by the participants served to isolate various attributes or mechanics that were used by individuals in responses to three stimuli; 1. Disengaged, 2. Engaged, and 3. Connected. These stimuli combined with the task of creating a patterned representation with the given shapes (circles, squares, and rectangles) provided constraining properties. In the case of the two circles and three word stimuli, the only way that participants could encode unique patterns for each word was to adjust the distance between the shapes as circles by their nature due not allow for alignment variation. Through this isolation and pattern analysis, participants' responses showed a strong tendency to place circles at great distances from one another to represent disengagement and place the same circles either touching or at a reduced distance from each other to represent connected (figure 8). This identified *'proximity'* as an attribute for encoding relationships (disengaged, engaged, and connected).

The same exercise was repeated for two squares which introduced the possibility of alignment (orientation) as a mechanic that individuals could utilize in spatial encoding. After analysis was complete, there was an increased tendency for both proximity and orientation to be used in creating patterns for each task. Again, proximity was by far the leading mechanic and some form of alignment was event. Like the circles, the squares were place at greatest distance for disengaged and the closest distance (or touching edges) for connected. The orientation of the squares was non-aligned for disengaged and aligned (or touch common edges) for connected.

Ultimately, the final set of patterns that came to be analysed were the rectangle pairs. The findings reflected those of the squares but in this case the participants had the increased latitude of being able to orientate either short or long edges. Both distance and edge alignment were consistently produced in response to the task of assigning patterns for the three stimuli words. One point of difference between the square exercise and the rectangular one was that the majority of the participants completed the final connection pattern with two long edges aligned and touching. Based on these final outcomes, both *'proximity'* and *'orientation'* were the two main attributes used in spatial encoding based on the constraints of the study and *'proximity'* was more dominate that *'orientation'* as a system for conveying various states in a pattern relationship.

4.2 Theories in spatial hierarchy

Having isolated the two attributes of *'proximity'* and *'orientation'* from the primary study this research then examined these finds and how they might integrate with other theoretical visual organization laws. Grouping plays a significant role in visually identifying relationships and acts as a way of dividing an environment or perceptual field into natural units (Pomerantz, 1981). These natural units are spontaneously assessed by the observer as a means to identification for potential action. Researchers agree that simplification via grouping of one's visual environment is used to ascertain the perceived properties of a given pattern or set of patterns (Rock, Indirect Preception, 1997). Traditionally there are three main classifications of these phenomena; 1. organization of space, 2. of shape / form, and 3. of movement. In each case these are attributed the being the most likely factors that will influence grouping. Space as a constraint is described by size (scale), distance, slant (orientation or alignment). Shape / form is the outline or silhouette of the object and form is the volumetric attributes that the shape has. Movement being the transformation of an object through a visible space not to be confused with the motion parallax that occurs when an observer moves through a space (Hochberg, 1981). In Gestalt grouping there is a division of two factors that influence tendencies of association in combination with the base concept of figure-ground. The first is the 'Laws of Grouping' (Rock, Perception, 1984) which would include similarity, proximity, or common fate as well as other specific types of grouping phenomena and the other factor is the concept of Pragnanz or good continuation. Pragnanz is a factor that states that the "visual field will group so as to yield the best, most stable organization" (Pomerantz, 1981).

Upon review of these laws, both proximity and similarity (orientation) are present in the previous primary study but the question arises, how do these fit within a greater hierarchy of visual organization? To address not only the concept of grouping but the potential of hierarchies within grouping, this theoretical examination moved beyond the basic Gestalt laws and examine the works of researchers that have pursued further study in this arena of spontaneous visual organization.

One researcher that has spent a significant amount of time studying and refining potential hierarchies within the Gestalt principles of grouping is Stephen Palmer (UC, Berkeley). Concerned with reviewing the laws of grouping that Gestalt had developed at the begin of the 20th century, he found these laws to be useful in describing certain phenomena but had issues with the limits of these laws in accounting for multiple factors in the perceptual process. Specifically he describes two major difficulties with Gestalt at the time of his proposed theory… *"1. Their (Gestalt) laws are purely qualitative and 2 that they never suggested ways in which the different factors could be integrated"* (Palmer, 1982). In an effort to better address these concerns, he proposed a "Transformational Theory of Perceptual Structure" that was partially focused on the use 'spatial analysers' within a visual system. Palmer used the term 'spatial analyser' to refer to the brains ability to aggregate and organize spatial information given by a set of sensory elements within a certain visual field or 'sensory mosaic' (Palmer, 1982).

> "…spatial analyser is a computational abstraction - a black box if you will - whose inner workings and physical realization do not concern us. When we discuss an analyser, then, we are really talking about a function computed over space by a hypothetical device." (Palmer, 1982)

Within this examination of spatial analysers, Palmer proposes that the way they operate within the visual system can be categorized by position, orientation, sense, and resolution. Additionally, he went on to develop an ordering system or level for the various analysers. First, Second, and Third order analysers are composed of the following; First Order is the attention to static elements within a sensory mosaic - position, orientation, and size. Second Order analysers are related to motion (displacement) and rate (velocity) and Third Order analysers are utilized in examining acceleration. Most of Palmers theory is perhaps far too detailed for the purposes of this discuss but this foundational work was informative with particular focus on first order analysers as they relate to position, orientation, sense (size), and resolution. He uses these factors as they relate generally to the established Gestalt laws and compares how they may interact in a given set of stimuli. Meaning what are the predominate factors, what are their potential order of influence, and how do these interact with each other?

Palmer's work would indicate that "spatial proximity is perhaps the most basic organizational factor" (Palmer, 1982). Proximity is a relative characteristic and that is where the resolution of that proximity comes into place. Resolution being the intensity of interactiveness or the distance that a set of patterns is in relation to another pattern. Take for example the case of displaying a triangle, a square, and a circle which all have different shape and potential orientation indicators. If the square and the circle are place in close proximity to each other and the rectangle is placed at a significant distance from the first two then the circle and square will be grouped with each other thus implying that the spatial distance is a stronger indicator of grouping that the shape or orientation of a given visual array. All this is to point to the fact that proximity is often the dominate factor in decoding spatial relationships (Palmer, 1982). Palmer makes clear that although proximity tends to be the most basic organizational factor it is almost always a case of relative magnitude.

> "Whether orientational grouping would dominate proximity grouping is clearly a matter of the relative magnitude of each sort of relatedness. If the orientational difference is small and the positional difference is large, the proximity should dominate. The opposite situation should produce the opposite result." (Palmer, 1982)

As Palmer theory is elaborated, he references the research work of Beck (1966) to address the relative dominance of orientation over shape. In Beck's experiments, he showed that the tendency of orientation (T shapes vs. L shapes) as a more powerful organizer that the shape of the actual stimuli. From these and other experiments, Beck showed that at least for these particular conditions that orientation leads shape similarity in a hierarchy of grouping. This is not to say that shape similarity and comparison of that similarity is lacking in its potential impact on grouping but simply to say that the tendency is for orientation to be the dominate factor. In addition, orientation can serve to effect the perception of two similar shapes (Rock, Perception, 1984). If similar shapes are at a different orientations this can have a tendency to lead to inaccurate shape perception; in this case the alignment of orientation can improve the power of form similarity on perceptual grouping. To isolate the impact of shape comes down to the invariant structures that lie within a given shape. Invariants are typically described as quite simply the qualities of an object or stimulus pattern that do not vary or remain constant in proportion and relationship to each other (Gibson, 1979). When multiple shapes are compared in a visual grouping scenario, the invariants proved additional discriminating input to the perceiver that allows for an additional level of organization (Palmer, 1982).

4.3 Perceptual protocol for encoding relationships

Palmer's Transformational Theory of Perceptual Structure is much larger than the elements that were highlighted in this paper and tend to encompass theory from not only Gestalt but Ecological and Information Processing psychology. It also examines the role of motion (both environmental and observational) as the title implies. Considering the elements that I have selected from his work for this discussion it is important to note the ordering within grouping that this theory proposes if only at a first order. In first order spatial analysis (static), position (proximity) leads orientation which in turn has a stronger influence on organization when compared to form similarity (shape). Within form similarity, the invariants of a particular shape can have an additional influence on organization as well. The summary in spatial hierarchy combined with the findings from the primary study, were then visualize in a bottom-up pyramid as a way of establishing a 'perceptual protocol' resulting in an encoding process between physical objects to create the meaning of relationship or connection (figure 16).

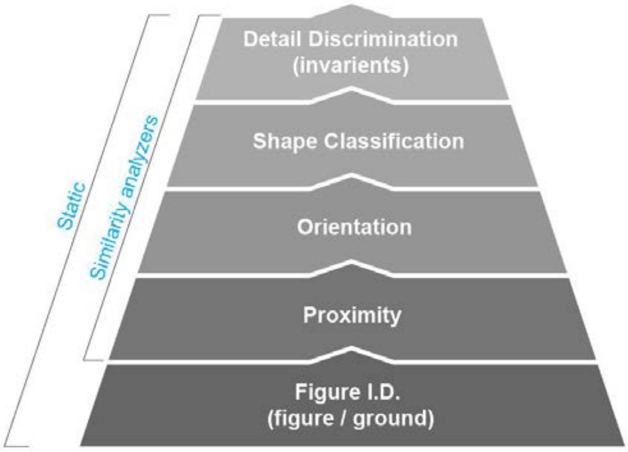

Figure 16. Perceptual pyramid for encoding spatial relationships

The previous discussion was an effort to examine various perceptual theories and how they could be applied to a digital device relationship encoding process. The aim is that this process will be useful in creating an approach to designing qualities that may aid in the user's understanding of wireless relationships.

5. Limitations

The challenge to this study was to identify how users can create through action the relationship state that they desire between two Bluetooth devices. To that end, it was important to isolate the mechanics that participants utilized in spatial encoding. If it were merely a study of perception and not action then the study could have focused solely on visual grouping and the factors that influence the inclination of these groupings in a bottom-up process (lower order leading to higher order cognition). For this reason, it was important to have participants create *spatial generations* (patterns) based on word stimuli versus having them describe *spatial analysis* based on form stimuli. That being said, the insights resulting from this experiment coupled with the theoretical foundations in perception can be considered descriptive and direction in nature. These could be enhanced through the replication of this study on a larger sample size. Additional factors that could have directly influenced the findings were the constrained nature of the primitive forms used in this study (circle, square, rectangle) as they were predominately flat and void of a vertical dimension. Lastly, the alignments in orientation that the participants created could potentially be attributed to the environmental constraint of a rectilinear piece of paper. This rectangular paper could have directly affected the participants form generation as it implicitly provides orientation that contributes to the overall mapped relationship between two forms and their environment.

6. Conclusion

With increasing shift from a wired to wireless world, there has been a loss in the visual mapping that these wires once represented. This representation is that of connection and relationship between two or more digital objects. As this wireless ad hoc world continued to expand, design must play a role in utilizing the physical and tangible qualities of objects to create a new semantic approach to pairing. This studies aim was to provide insights into the mechanics or attributes that participants utilize in creating paired relationships between objects for the purposes of informing a tangible approach to creating paired relationships between Bluetooth devices. The resulting findings from the primary study indicated that 'proximity' and 'orientation' were the key drivers that individuals utilized in encoding relationship qualities between two forms. The previous deep dive into spatial organization and visual perception was an effort to couple the findings from the primary study with additional theory so as to propose a foundational protocol or framework for encoding relationships between Bluetooth digital objects. Utilizing these study findings and perceptual theory as a means of informing a new way of leveraging the gestures or spatial relationships to define what is connected in an ever expanding wireless world. This proposed protocol could serve as a foundation for designers as they continue to develop new tangible interactions between objects and users.

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Serious Play Strategies in the Design of Kinetic and Wearable Devices

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Abstract: Encouraging spontaneous creativity is an on-going quest in design. Play embodies this. This paper builds on the concept of "serious play" as a design strategy for creating new and innovative ideas. It discusses a qualitative study involving six teams of designers, each generating initial concepts for wearable and interactive kinetic devices. It describes the playful interactions that emerged as a common strategy for their collaborative and creative ideation practices. It contributes features that further clarify the nature of serious play in relation to humour, role-playing scenarios, gestures, and multi-sensory involvement.

Keywords: collaborative design processes; humour; role-playing scenarios; gestures; multisensory explorations

1. Introduction

Design teams use different strategies to create new and innovative ideas. Serious play is one of these strategies. Serious play is defined as working in a fun or playful way to achieve a fresh or novel solution to a complex problem (Palus and Horth 2002; Statler, Loizos Heracleous, & Jacobs 2011; Rieber, & Matzko 2001; Rieber, Smith, & Noah 1998). This approach to innovation encourages participants to communicate ideas in a safe manner, as there is a degree of foolishness already built into the activity (Hinthorne, & Schneider 2012; Statler, Loizos Heracleous, & Jacobs 2011). It encourages creativity and collaboration. Playfulness relaxes group tensions, brings out a childish creativity that can result in outside-the-box ideas, and reduces status quo assumptions (Hinthorne, & Schneider 2012; Rieber, Smith, & Noah 1998; Weissman 1998). Playfulness assists in motivating participants to engage with a task, encouraging reflection and critical thinking (Rieber, & Matzko 2001; Rieber, Smith, & Noah 1998).

This paper reports on findings from three design workshops in which participants were asked to generate kinetic concepts for personal alarm devices that would use alarms to alert people about specific times or timed events. All the design teams, in different cities, resorted to serious play to generate ideas. Their serious play was characterized by:

- Humour, which was used in all groups to present new ideas and concepts;
- Role-playing scenarios, which were used to explain ideas and concepts and brought out additional features that were not apparent during ideation;
- Gestures, which were used as a communication tool, similar to and in addition to sketching;
- Multisensory explorations, which may be viable components of a serious play approach to designing wearable or interactive devices.

2. Background

2.1 Fixation

Designing new and novel devices that are wearable and have sensory or kinetic elements is a non-trivial task. Part of the problem could be due to fixation. Fixation is when designers cannot see past common features that are already in existence. Designers can be limited by what they are familiar with and are therefore blocked from seeing new innovative solutions (Cross 1982; Crilly 2015; Atilola & Linsey 2015; Youmans & Arciszewski 2014; Hatchuel, Le Masson & Weil 2011; Jansson & Smith 1991). Since there is low risk associated with using concepts or features that are proven, fixating on past designs is a safe path for designers (Youmans & Arciszewski 2014; Hatchuel, Le Masson & Weil 2011). Whether intentional or not, existing knowledge about successful products influences decisions and can create difficult boundaries between designers and truly novel ideas (Youmans & Arciszewski 2014; Hatchuel, Le Masson & Weil 2011).

Fixation usually appears in the early stages of design development (Crilly 2015; Youmans & Arciszewski 2014). Though early brainstorming can generate many ideas, these ideas may not cover a large range of design options or features (Hatchuel, Le Masson & Weil 2011). Moreover team members can influence each other to create similar ideas in brainstorming, limiting creativity (Youmans & Arciszewski 2014; Hatchuel, Le Masson & Weil 2011). Groups may also be influenced by examples given to them in early stages of a design task. This varies with the type and quantity of examples provided (Atilola, Tomko, Linsey 2016; Vasconcelos &, Crilly 2016). Ensici et al. found that groups abandoned “fun concepts” as they could cause tension in the group (Ensici, Badke-Schaub, Bayazit, & Lauch 2013). However, group ideation as a form of serious play has also been proposed to help fixation, as multiple perspectives in a playful context can break singular thought patterns (Crilly 2015; Palus and Horth 2002).

2.2 Humour and Ideation
Humour also has the potential for breaking through this fixation. It has the potential to enhance the group's mood and creativity; through playfulness it is easier for people to "change frames of reference" (Wodehouse, MacLachlan, and Gray 2014). Humour can break down tensions that may arise in group settings (Cundall 2007). It can diminish conflict between members and strengthen group dynamics (Cundall 2007; Cross & Cross 1995). Also, laughter lowers the perceived risk factor for members presenting new ideas (Mayo 2010; Cundall 2007). Laughter releases endorphins and encourages other positive physiological reactions, allowing group members to relax (Wodehouse, MacLachlan, and Gray 2014; Weinlick 2010). Humour is a form of comfortable, safe communication that can encourage creativity (Wodehouse, MacLachlan and Gray 2014; Weinlick 2010). The comfortable, safe and fun environment can reduce stress and inhibition in presenting new ideas.

2.3 Role-playing in Scenarios
Another means of coping with fixation is role-playing. This is another well-known and playful method for creating new ideas in the initial phases of a design project. Design scenarios are stories with plots that portray users' goals, behaviours and experiences for reflective, evaluative and generative purposes (Caroll 2000b; Iaccucci and Kuutti 2002; Garabet, Mann and Fung 2002; Jonas 2001). This role-playing technique was influenced by the collaborative theatrical dramaturgy of Boal, Zaporah, and Johnstone, as well as improvisational musician Nachmanovich (Boal 1992; Namanovich 1990; Shyba 2008; Iaccucci and Kuutti 2002). Designers often enact scenarios to create ideas and concepts for an imaginary future, using simple prototypes of their own creation (Atasoy and Martens 2011; Bødker 2000; Carroll 2000; Iacucci and Kuutti 2002). Scenarios also help designers communicate ideas to one another because they provide context, define a problem space, and allow for consideration of multiple perspectives (Bødker 2000; Caroll 2000a; Jonas 2001; Pedell & Vetere 2005). This last point is important when team members' backgrounds vary; to maintain agreement everyone must understand the problem and ideas presented.

According to Iacucci and Kuutti, these "Informance" enactments "are intended to explore design ideas in ways that are generative rather than analytic'' (2002). When designing a product, scenarios can help designers focus on identifying benefits of the product in light of the user's goals (Bødker 2000; Jonas 2001; Carroll 2000a). Experimenting with a rough prototype in a scenario can help designers reflect on their concepts and identify flaws in their design (Bødker 2000; Jonas 2001; Pedell & Vetere 2005**;** Carroll 2000). In this study the designers were instructed to play-act possible scenarios of use to encourage such reflection.

2.4 Gesture as Design Tool
Design explorations involving bodily movements or gestures have been shown to contribute to developing novel design ideas (Buchenau and Fulton Suri 2000; Hummels, Overbeeke and Klooster 2007; Gray, Brown, Macanufo 2010; Schleicher, Jones and Kachur 2010; Vyas et al. 2009). These methods have been referred to as body storming, embodied storming, role-

playing, design choreography or a design movement approach. Vyas, Dirk et al (2009: 164) note that many “bodily actions were aimed at better understanding of the design task context and at exploring new possibilities”. Gestures are also discussed as a way lightening the cognitive load when used in combination with speech (Klemmer, Hartman, and Takayama 2006; Tang 1991:in Vyas and Dirk et al 2009). Hummels and Overbeeke argue that gestures are emotive and expressive, as well as useful for stimulating idea generation. They conducted a study comparing the value of traditional sketching with the value of gestures for capturing “expressive design concepts” (2007: 684). They did not find any significant difference for the designers’ satisfaction with the outcome of objects made using one technique or the other. They note, that gesturing can serve as a design tool, although designers have little training in the use of gestures (Ibid). Tang and Leifer (1988) suggested that gestures can even replace sketching or visuals in the early design phases, however research in this area is limited.

Gestures have also been identified as a common form of communication in the early stages of design (Bekker, Olson, & Olson 1995; Cross 1982: Tang & Leifer 1988). However, gestures in the design process are difficult to research, as they leave no physical trace (Tang & Leifer 1988). Gestures are used to both enhance verbal description i.e. indicating size or activity (Bekker, Olson, & Olson 1995; Tang & Leifer 1988) and to provide non-verbal cues (Holler 2010; Bekker, Olson, & Olson 1995). They convey additional information in the design process such as describing the object, suggesting alternative form factors, referring to specific locations, pointing to drawings or lists, clarifying verbal points, and simulating use, among others (Bekker, Olson, & Olson 1995; Harrison and Minneman 1994). The literature acknowledges that gestures are integral in face-to-face design meetings and “active participants in speaking and thinking” (Bekker, Olson, & Olson 1995; McNeil, 2005).

Gestures can be classified by their anatomy, their use, and their meanings (Bekker, Olsen and Olsen 1995; McNeill 2005; Streeck 2011). This paper builds on previous research into gestures as a design tool (Frankel, 2014). These gestural categories are loosely derived from the “gesture ecologies” of linguist/sociologist Jürgen Streeck (2011). They include: i) evoking gestures in which bodily movements and narratives explore and communicate tacit knowledge, ii) conjuring gestures in which a person uses gestures to enact and enhance his or her verbal explanation of possible or imaginary ideas for something that could exist, and iii) structuring gestures in which bodily gestures are simultaneously reinforced through talking and making things that communicate tacit or latent knowledge. Here visual representations or sketches also accompany gestures.

2.5 Multi-sensory design explorations

Sensory explorations also have the potential to enhance idea generation and produce novel product interactions (Abram 1997; Bull 2006; Malnar & Vodvarka 2004). Sensory aesthetics can enhance pleasurable product experiences (Jordan 2000; Norman 2004). Through the exploration of the overall sensory context of product/user interaction designers may come to deeper insights about appropriate product features (Desmet and Hekkert 2007;

Overbeeke et al. 2003; Schifferstein and Hekkert 2008). In this study, designers were encouraged to consider non-traditional sensory features for their design concepts.

3. Summary and Research Question

The literature review found that designers may be inhibited by fixation on existing solutions to similar problems and/or negatively influenced by team members. These tensions may be relieved by humour or by enacting proposed ideas through bodily movements such as gestures.

Through role-playing in scenarios designers can experience their problem space and reflect on the ideas being generated. In addition, developing a greater awareness of a range of sensory contexts of use may provide insight into novel sensory features. By focusing on these aspects of serious play, it may be possible to further clarify its features in relation to collaborative design team practices. As a result, the research problem was to encourage team innovation, collaboration, and scenario building, without specifying how participants should interact with each other. Initially the study investigated whether, given a kinetic design problem, participants would engage in a variety of gestural and sensorial practices. As findings began to emerge, this seemed too limiting and the question evolved into a more general focus on how participants would interact, given a design problem that focuses on generating kinetic design concepts through collaborative scenarios.

4. Method

To investigate serious play in the design of kinetic, sensory wearable devices, three design workshops were held. At the beginning of each workshop participants were shown examples of kinetic alarm clocks with unusual sensory and kinetic features; they were not wearable. These concepts were highly idiosyncratic and humourous. The designers were then given a brief questionnaire. This questionnaire asked about types of existing alarms that people depend on, scenarios in which alarms may alert a person that the "time" has come to do something, and different sensory or kinetic alerts such alarms could have.

Participants worked individually at first and later shared and discussed their answers with the entire workshop team. These ideas were divided into related concepts based on criteria decided by the participants. The participants then organized into subgroups based on this division.

In the smaller groups, participants were instructed to "please use traditional techniques of sketching and modelling, as well as play acting as a way to understand the user's experiences in all stages of using this new type of alarm". They were provided with supplies such as plasticene, tin foil, feathers, stickers, pipe cleaners, food, and traditional sketching materials to create and build rough prototypes. At the end of the task groups would act out their scenario with the prototype. The teams would then have a reflective conversation about key features and ideas.

Each workshop was filmed to capture the design process, body movements and gestural communication, with the participant's consent.

5. Participants

Three workshops were held in three different cities: Canberra, Australia; Brisbane, Australia; and Ottawa, Canada. The participants ranged from emerging designers with an approximate age rage of 18-40, to more experienced designers with an approximate age range of 40-65. There were 8 male participants and 10 female participants. The participants formed 6 groups, as shown in table 1.

Table 1 Workshop Group Compositions

Group	Location	Approximate Age Range	Male Participants	Female Participants	Total Group Members
A	Canberra, Australia	31-65	1	2	3
B	Canberra, Australia	31-65	0	2	2
C	Brisbane, Australia	22-40	2	2	4
D	Brisbane, Australia	22-25	3	1	4
E	Ottawa, Canada	26-35	1	1	2
F	Ottawa, Canada	18-25	1	2	3

6. Findings

The analysis of the three workshops revealed that team behaviours fell into one of the four categories previously discussed. These include: the uses of humour, approaches to enacting scenarios, gestural tools, and attitudes towards non-traditional sensory alerts. In general groups of two worked on a single device. There were two groups of two: Group B and Group E. Group E created a wristband for directional alerts. Group B created a device for emotional alerts that could be worn as a headband or a wristband. Although the device could be worn in two ways it was still a single device.

Groups greater than two worked on a system of products or multiple individual products. For example, Group A worked on a dog monitoring device for gardens that had two wearable components for communication exchanges with a robotic dog that would gather data in the garden. Groups C and D also created systems of communicating devices. In Group F, each member created his or her own device under a common subject of self-improvement. In all cases with groups greater than two members more than one device was created.

Groups that were less outgoing tended to hesitate in committing to a concept or scenario. Group E had only two members and both were shy. They did not commit to an idea and scenario until the last ten minutes of the workshop. Outgoing groups tended to commit to a general idea or scenario earlier in the process. Group B, was composed of very talkative members who made their decision confidently within the first five minutes of the workshop. In all groups when members were all able to decide on a common scenario design decisions were made with much less hesitation.

6.1 Humour and Idea presentation

Groups used humour in their design process. This humour often was associated with the presentation of a seemingly ridiculous idea. In every group laughter and joking accompanied an idea that was uncommon in current products or perceived as a preposterous feature. However, many of these ideas were eventually integrated into the devices. A member of Group E, laughed while mentioning a sonar ping being used in their device. This ended up being a key feature. Or in Group F a hologram component was originally proposed as a joke, but appeared in the final product. Group B and some participants from Canberra and Ottawa joked about an electric shock as a feature. Group B ended up with a shock as one of their alerts. Humour supported innovation.

6.2 Role-playing scenario development

As part of the instructions the groups were encouraged to enact a scenario for their products. Making decisions about the scenario led groups to modify and add features to their products. Even the groups less comfortable with acting out (Group E) scenarios discovered that they must add/modify features of their product to be able to enact the scenario. The discussion of the scenarios led groups to final design decisions and mutual agreement of a feature's usefulness. For example, Group C was unclear what their product would be until they agreed to focus on children getting ready for school. After the scenario was decided upon, the design features were developed and added or eliminated, such as incorporating a backpack to keep track of items the child has for school. Group B experienced a change in their device by adding on/off features when planning the final scenario.

Individual participants would often role-play mini scenarios to convince other members that product design ideas were necessary. For example, in Group F when brainstorming positive alert systems, the team member proposing the idea demonstrated the difference between being woken up by a kiss and a buzzing alarm. This example moved the group into the direction of positive reinforcement alarm systems, which became their final theme.

6.3 Gestures as Communication

All groups used sketching and writing in the early stages of the workshop but soon abandoned these for gestures. During the ideation and building stages, very few groups used sketching as a means of interacting and communicating. Group C stayed in sketching individually longer than other groups. Group E was the only group that relied heavily on sketches and showed their sketches in the final workshop presentation. The group members were very shy and uncomfortable with acting out scenarios.

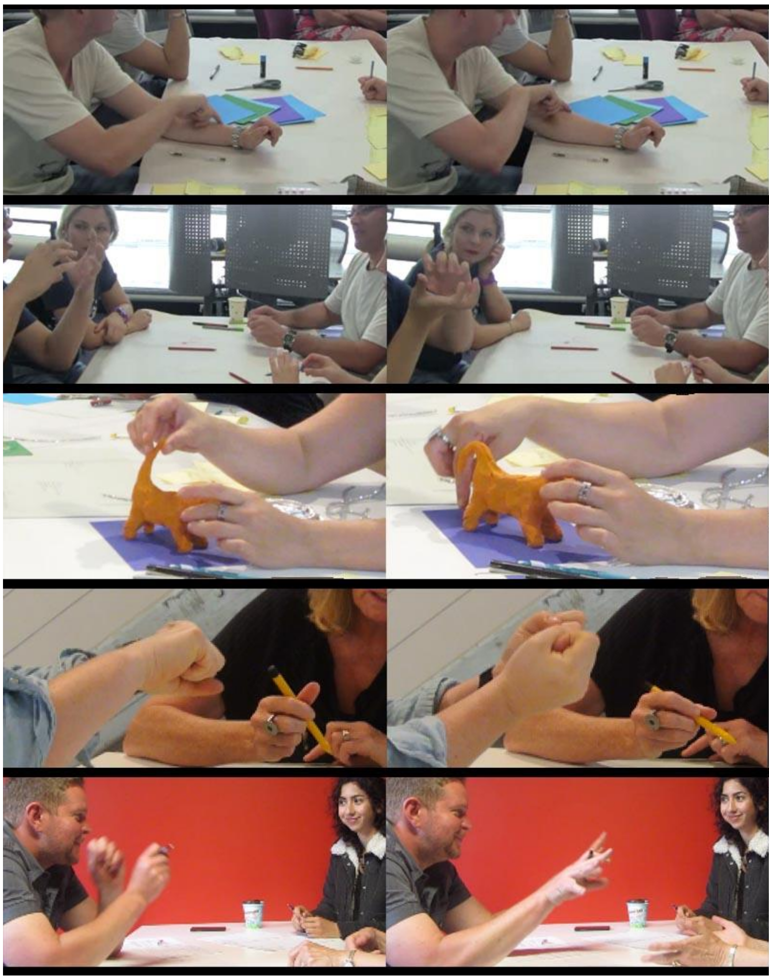
Gestures were used between group members to describe different aspects of an idea. The use of gesture can be broken into three major categories: communicating, concept description, and user experience.

Communicating gestures are gestures that are related to the speaker's behaviour. These gestures focused on a list of options, difference between items, indication of frustration within a group and gestures used to ask a question or give a response. Communication gestures include counting using fingers or using hands to show one option over another. Examples of communicating gestures are illustrated in Figure 1.

Location:	Brisbane
Gesture:	Counting ideas on hands while explaining
Description:	Listing (conjuring)
Location:	Brisbane
Gesture:	Using hands to indicate user switching fitness acitivity
Description:	Difference (conjuring)
Location:	Canberra
Gesture:	Point to wearable and ask about function
Description:	Question

Figure 1 Examples of Communicating Gestures

The **concept description gestures** described the physical design of the product. Concept description gestures refer to function, material, sensory or kinetic alerts, how the device is worn or products that already exist. Examples of concept description gestures are illustrated in figure 2. Concept gestures involved hand movements that mapped out the product in space. In some cases participants used each other to indicate where something would be worn or tactile alerts such as vibration. The description of conceptual features was the most common use of gesture in all workshops and provided more information than sketches did in this study.



Location:	Brisbane
Gesture:	Showing how device is connected through veins
Description:	Existing product (conjuring)
Location:	Brisbane
Gesture:	Modelling shape change in air with hands
Description:	Kinetic/Sensory (conjuring)
Location:	Canberra
Gesture:	Using prop and gesture to indicate soil probe
Description:	Function (conjuring)
Location:	Canberra
Gesture:	Bending hand movement to describe material type
Description:	Material (conjuring)
Location:	Ottawa
Gesture:	Moving hands in and out mimicking sonar pings
Description:	Function (conjuring)

Figure 2 Examples of Concept Description Gestures

User experience gestures described a person who would use the device and their interaction with the product. They included activities the user would be doing while using the product, who the user is, or the time and location of the user's product use. Examples of user experience gestures are illustrated in figure 3. Experience gestures involve acting out scenarios, and mimicking activities. They express practices as well as interactions between the product and the person.

Location:	Brisbane
Gesture:	Miming user typing and programing device
Description:	Activity (evoking)
Location:	Carleton
Gesture:	Food as prop for user, away from work area
Description:	Activity (evoking)
Location:	Ottawa
Gesture:	Usingl hand movement to show time passing
Description:	Time (evoking)

Figure 3 Examples of User Experience Gestures

6.3 Wearable, Sensory and Kinetic alerts:

The initial ideation stage involved brainstorming different sensory alerts. Ideas for engaging different senses were expressed. Ideas of taste or smell were discussed in some groups, an uncommon method of alerting a user to an event. For example, Group F discussed a hormonal alert system; Group A discussed a scent alert. In the initial stages individuals proposed taste alerts for drinking too much alcohol, and a scent alert for taking pills. The workshop instructions encouraged this range of sensory possibilities. However, as final designs were formed the groups abandoned most of the senses and stayed with commonly found product interactions. As shown in table 2 groups used interactions including: visual alerts such as light, or colour, auditory alerts such as a beep, or buzz, and tactile alerts such as vibration. No groups engaged smell or taste as a method of interaction, rather the design stayed within an existing standard range of interactions. One participant noted that scent would be too confusing in a public area. The wearable component of the project was very similar, as most groups used a watch style wearable. Groups A, B, C, E and F used wristbands for at least part of their final alert system. Group D created a sock and earpiece. This was the only group to not use a wristwatch wearable.

Table 2 Final wearable interactions

Group	Wearable Component	Auditory Alert	Visual Alert	Tactile/Kinetic Alert	Scent/Taste Alert
A	Wristband	Sound alert			
	Necklace		Input keypad only		
B	Wristband/ Headband		Coloured Light	Electric shock (optional)	
C	Wristband		Text alert		
	Necklace		Text alert		
D	Sock			Compression	
	Earpiece	Audible vibration		Vibration	
E	Wristband		Light and screen with map	Vibration	
F	Wristband 1	Unpleasant and pleasant sounds	Light and colour change		
	Wristband 2		Light that projects on arm		
	Wristband 3		Hologram that grows/shrinks		

7. Discussion

7.1 Evidence of fixation

The task given to the designers was to create novel wearable personal alarm devices that had a sensory and kinetic component. The devices did not have to be implementable and could be completely imaginary. The guidelines were left open to encourage participants to think creatively and without restraint. However the final products demonstrate that fixation took place. Currently wearable devices are associated with wristbands (i.e. Fitbit or Apple watch). The designers are familiar with these products. Five out of six groups chose to use a wristband for feedback even though they could have created any type of product. This is evidence that even with complete freedom in design, designers tend to be limited by existing products (Youmans & Arciszewski, 2014; Hatchuel, Le Masson & Weil, 2011). Interestingly, the designers with more experience were, for the most part, more fixated on existing and practical solutions.

Fixation can also be seen in the alerts. Designers were told to consider all senses. However the interactions in the majority of final products were similar to any smart phone device.

Holograms and projections offer a more unconventional interaction, but the participants steered away from the taste and scent alerts. Taste and scent alerts were either overlooked by groups or viewed as too confusing for the user. The groups made these assumptions without justifying them, except in the one case where a participant said scent would be too confusing to distinguish in a crowded space. They did not mention other sensory confusion in crowded spaces such as audio interference.

7.2 Humour and Ideation

The humourous video examples of other kinds of personal alarms shown initially may have primed the use of humour in all the groups. The participants were given a large amount of freedom in their task and taking advantage of the opportunity, participants often presented their ideas in a “wouldn’t it be funny if we made…” joking manner. These ideas were outside the norm and seemed to overcome the fixation described above, confirming the literature. Ideas presented in this humorous fashion spun into ideas that made it to the final product. The laughter and joking seemed to encourage creativity and ideation in the groups.

Humour appeared in all groups. As indicated in the literature, it appeared to be used as a tool by individual participants to present far out ideas to the group without risk (Mayo, 2010; Cundall, 2007). The fun and joking generally created a positive group dynamic. Ideas presented with laughter were unconventional. Participants seemed to be more excited by ideas when they laughed about them. Humour was viewed as a positive element in the workshop. Results confirmed the literature that humour relaxes team members, lowers perceived risk, and strengthens team relationships, even in the case of timid designers.

7.3 Scenarios and Role-playing

Our observations confirm the literature. Participants who used mini scenarios to help illustrate ideas were well received by group members. Creating the final scenario and acting it out with simple prototypes allowed groups to reflect on the user’s goals and to fine-tune the appropriate product features (Bødker, 2000; Jonas, 2001; Carroll, 2000). Acting out imaginary scenarios with simple artefacts provided a playful opportunity for the designers to explore, evaluate, and refine the interactions between the proposed concepts and users’ needs. The scenario development occurred in iterative stages of planning, modifying, enacting subsets, and overall scenario acting. This facilitated and increased understanding among team members.

7.4 Gesture as Design Tool

As indicated in the findings, the prominent types of gestures used were conjuring (illustrating tacit knowledge) and evoking (illustrating latent knowledge). They were organized into communicating, concept description, and user experience gestures. Communicating gestures reflected the designer’s personal behaviour, and were often unique to the person. Concept description gestures focused on possible ideas or what could be, primarily including conjuring gestures (Frankel, 2014). User experience gestures focused on a past or present action, or used an evoking gesture (IBID).

Very few structuring gestures were used in the activity. Pure body gestures replaced physical artefacts. Gestures were treated as an essential visual communication tool between participants as other visual tools were not used, which further confirms Tang and Leifer's (1988) suggestions. The conjuring and evoking gestures played a vital role in communicating physical product design in scenario development. In support of the literature, gestures were common in this initial design phase, as independent tools and in conjunction with verbal descriptions (Bekker, Olson, & Olson 1995; Holler 2010; Tang & Leifer 1988).

7.5 Limitations

In the end, multi-sensory explorations did not contribute to novel ideas, but were considered as out-of-the-box possibilities along the way. This may have been due to the lack of other sensory samples or materials for the teams to work with, such as materials with a variety of scents and/or a range of tactile qualities. More research is needed in this area. In addition, the sample of design teams was small, and could be expanded in future studies. The role of humour and serious play in overcoming fixation could also be investigated further.

7.6 Serious Play Clarified

Serious play is a comprehensive design approach that incorporates familiar design research techniques. It was key to the process of exploring the design of a kinetic and wearable device in this study. As the findings demonstrate, fixation– even with complete freedom– is an issue for designers with the potential to limit innovation. However this study suggests that serious play has the potential to defuse fixation at phases in design team interactions. It shows promise for minimizing conflict within teams and maximizing collaboration through humour, play, and iterative reflection. It is an activity that team members seem to intuitively understand– laughter accompanies non-traditional ideas, softening the potential for peer rejection. In addition, role-playing adds an improvisational and iterative opportunity for teams to generate and refine concepts along a structured storyline. While this process is described in detail in the literature, the added value of humour in role-playing activities seems to be downplayed in seminal works (Caroll 2000a & b; Cross 2006).

Gestures as team communication and design tools are also useful for serious play activities. The team members' gestures in this small study aided in understanding, description, clarification, and illustration throughout. The different types of gestures described user actions or future concepts in a temporary and informal manner. They served a function similar to sketching, but without the necessary skill of sketching and with the need of a group as audience. Gestural communication in groups is well documented in the literature in many fields, but less so in the design literature as a tool that designers can learn about, practice, validate and consciously incorporate into collaborative design processes (Hummels, Overbeeke and Klooster 2007). This is worth more study, especially as applied to educating designers. The multi-sensory results in this study were disappointing, as sensory alerts such as scent were dropped in final products and wearables became consistent with what is already available. However, we believe that further study is needed to investigate how a multi-sensory approach can add an exciting dimension to serious play.

8. Conclusion

Serious play emerges as a design strategy that enhances collaborative design team processes. The results of the study confirm the literature that fixation is a problem in team design approaches and suggest it may be overcome by serious play. The features of serious play presented here include familiar design methods that incorporate humour, play-acting, gesture, and multi-sensory explorations. These well-documented techniques are combined as components of a serious play approach, providing more insight into what serious play can be in the field of design.

The study describes the value of humour and acknowledges its role in supporting team cohesiveness. It strengthens arguments in the literature about the value of humour for de-risking unusual ideas introduced into the design process, for creating a positive team environment, and for contributing to innovative ideas. It also confirms the literature in demonstrating how exploring scenarios for playing out the contexts of people's product experiences can provide iterative opportunities for reflecting and refining ideas. It acknowledges the significance of gestures as design tools, categorizing them into communicating, concept description, and user experience gestures. More emphasis on teaching gestural skills to designers could increase awareness and understanding in this team building activity. The categories of evoking and conjuring are more useful in collaborative scenario processes than structuring gestures are. It recognizes that multi-sensory explorations may be viable elements of a serious play approach to designing wearable or interactive devices, but more research is needed in this area.

Lastly, serious play seems to mostly encourage purposeful and creative idea generation, a relaxed working environment, and new ideas in collaborative design teams. Future research may address ways to involve more reticent team members in playful explorations and ways to incorporate direct user involvement in collaborative idea generation.

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Tangibility in e-textile participatory service design with mental health participants

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Abstract: This paper introduces a project in which members of the Nottinghamshire Mind Network are engaged in the participatory design of e-textile service networks informed by the Person-Centred Approach mode of psychotherapy. Early reflections on separate e-textile and service design workshops reveal two distinct functions of tangibility in this process. First, we discuss how we have attempted to make novel technical futures tangible for participants through the experience of making textile circuits and soft handheld objects. Second, we discuss our finding that the experiences of participants in the mental health sector can lack presence for relevant audiences; our response to this, in the form of collaborative film work is introduced. The paper contributes to the technical and participatory design communities in its presentation of the Person-Centred attitude to the configuration of potentially vulnerable user groups, and the development of a methodology for the inclusive design of embedded technologies.

Keywords: configuration of users; person-centred approach; e-textiles; Internet of Things

1. Introduction

The authors are part of a large multidisciplinary research team, which includes textile designers, human-computer experts and psychotherapists. The project investigates the Person-Centred Approach of Carl Rogers as a methodology and framework for design, in some ways critiquing User-Centred and even Human-Centred approaches for their embodiment of unequal power relations (Kettley et al in press). The Person-Centred Approach is differentiated from other therapeutic modalities by its non-directive and non-expert attitude. It is characterised by trust in the individual to grow and change (Wilkins, 2009:7), as well as the facilitative effect of therapeutic relationships (Rogers, 1957). The conditions Rogers identifies are empathic understanding (trying to put yourself in someone else's shoes), unconditional positive regard (warmth, valuing, prizing the other person and their experience), and congruence (being real, genuine, self-aware). In working with mental health, we view everyone as having mental health, experienced on a spectrum. We agree with Freeth (2007) that it is unhelpful and can be dehumanising to rely on a deficit model that prescribes diagnosis-treatment-cure as a response to distress and/or 'abnormal' experiences, processes or behaviours. Therefore we do not ask participants to disclose personal histories of mental health, and they are free to share any information – or not – as and when they choose. This is consistent with the principles that apply to the Mental Capacity Act (2005). In working with Mind service users there is an implication that participants have self-identified as experiencing mental health issues, and as such we ensure that at least one psychotherapist is present at workshops, along with Mind staff as appropriate, to provide support if required. This methodology is therefore differentiated from the standard intervention approach more normally found in technology application development, as it does not start with a population defined by a common medical condition. The contribution of the paper is to the debate on the configuration of users of technology, in this case, of e-textile interfaces in an Internet of Things.

The project is 18 months long, and includes three series of participatory workshops, intended as a whole to scaffold experiential learning around two near future concepts: electronic or 'e-textiles', and the Internet of Things. The first set of six workshops was held at Mind in Worksop, in the Midlands region in the UK. On average, six participants attended, although the actual number varied across sessions due to individuals' circumstances and wellness; this is a common characteristic of work in this field. The toolkit itself is intended as a convivial tool to facilitate both reflective and generative service design activities (Sanders and Stappers 2008), such as mapping personal journeys, identifying touchpoints, and developing stakeholder maps. The first two of these are most relevant at this stage of the project, based on discussions with staff at Mind, and drawing on the multidisciplinary workshop that framed the initial project proposal; in approaching emotional touchpoints it is important that we do not focus solely on negative stressors, but attempt to map the emotional management of the journey by each individual.

In between these sessions with mental health service users, we were invited to take our ideas to the Oakfield School and College in Nottingham, where we started to collaboratively develop one version of our participatory service design toolkit (figure 1). Oakfield is a large special needs school, attended by up to 160 children between the ages of 3 and 19. The participants at our workshops included current students and members of the 'NICER' group, an advocacy group of alumni, staff and students, who have extensive experience of working on collaborative design projects with an HCI flavour. The second set of six workshops, which runs between November and December 2015, collaboratively tests the content, structure and delivery mode of a novel participatory IoT service design toolkit. At the first session included two participants from the first e-textile sessions, although a third participant is expected to join sessions later on. Again, there were six participants.

The next section discusses approaches to the human at the intersection of participatory design, technology and mental health through an account of two extant literature reviews, and our own emerging Person-Centred methodology. The paper then continues with a discussion on the project's attempts to make e-textiles as an emerging IoT technology tangible (accessible) to the mental health co-researchers, and our attempts to make their experiences tangible for a range of disciplinary audiences through the design of the toolkit.

2. Configuring users: participatory design research with mental health service users

Mental health is considered "well represented" in the design literature review, based on a search of 11 databases from the viewpoint of a 'design outsider' (Chamberlain et al 2015, p. 11), "with 15 articles spanning mental health services, … fear therapy, … autism, … and depression …" (Chamberlain et al 2015, p.21). In addition, four articles were identified through the expert network, and six through the unpublished grey literature (p21). In this meta-review, autism was included, but dementia was not, in the definition of mental health. All of the four case studies focused on physical health (wheelchair design, visualisation of healthcare associated infections in clinical environments, the redesign of a resuscitation trolley, and a head support worn around the neck to improve posture and assist people with motor neuron disease. No mental health example was given (2015). Of the citations given as examples in the discussion of conditions (p21), one is concerned with social aspects of mental health (Carroll et al 2010), at least two deal with autism (Carroll et al 2010, Barakova 2011); and most are technology led, this being based on their being published in technology focused conferences and journals, and on the inclusion of such terms as 'robotics', 'web-based systems' and 'interactive systems' in the titles (Bae 2013, Bae and Heitkemper 2006, Sa et al 2012). Broader conditions like depression appear less frequently (Bae et al 2009). The second meta-review of the literature focuses on participatory approaches to the development of technology-based mental health and wellbeing interventions (Orlowski et al 2015). This review covers over 6000 citations, of which 17 studies were included in the systematic review, and focused on youth services. Of these, one reached the design proposal stage (Carroll et al 2010), and one was designed but not developed (Ekberg et al 2013).

In this review the authors identify four strands of Participatory Design (PD) in the literature: community based participatory research, participatory action research, participatory design, and user-centred design; of these, the first two appear to share core principles, and the reviewers see them as a single methodology, which strives to "develop an egalitarian partnership with a chosen community" (Orlowski et al 2015, p2). Participatory Design emphasises shared knowledge production and research outputs, while User-Centred Design remains led by an often implicit, but sometimes explicit, expert model (Sanders and Stappers 2008).

This literature review made use of the term 'intervention', commonly found in more behavioural approaches to mental health. In contrast we suggest an attitude more in alignment with 'entanglement', a term used with citizen science and publics research to describe the bringing into awareness for people of contested issues (which can include imagined opportunities and issues with near future technologies) (cf Lindström and Ståhl 2014). Such bringing into awareness, we suggest, is a form of emerging tangibility or presence of the technology for users, which allows them to question and propose diverse futures. According to Sanders and Stapper's map, such an attitude may be found most readily in generative participatory practices of design-led research (2008).

3. Making near future technologies tangible for mental health service users

This part of the paper describes the generative co-design of two service design toolkit concepts. The evaluation of the toolkits is divided into reflections on the physical components of the kits, and on the larger contexts of their creation and use. Critical incidents, both negative and positive notable moments, are used to illustrate the impact of some of the formal aspects of the kits on the experiences of individuals. Critical incidents are a useful way to organise reflection on practice and action-oriented heuristic research (Moon 2013).

Figure 1 Intitial concept for a service design tool, collaboratively developed at Oakfield School

The first concept for the service design toolkit comprised a laser cut wooden board with disc counters that could be slotted into holes to create a story (figure 1). Discs had images of objects, actions, and outputs/effects on them and these were discussed and extended collaboratively with the Oakfield School participants. Strings could be used to connect different elements of these stories. The second concept for the toolkit is based on serious play and the use of Lego in service design (Lab for Living 2014) (figure 2). It comprises a range of figures (human and animal), things found on walking through a town (trees, traffic lights, cars, roads etc), and boxes to represent buildings; small wooden bird houses are used to represent Mind. The elements of this kit have been somewhat creatively sourced due to time restrictions, and as a 'kit' there is a lack of visual coherence; as designers the urge is to rectify this, imposing an acceptable aesthetic according to our own professions. However, it may be that offering a range of options will allow individual responses to emerge in keeping with the person-centred ethos of the project. What is left for individuals to personalise with stickers, paint etc, and what is presented as choice through different forms of similar elements, is something we continue to work in as we try to optimise the kits for future use.

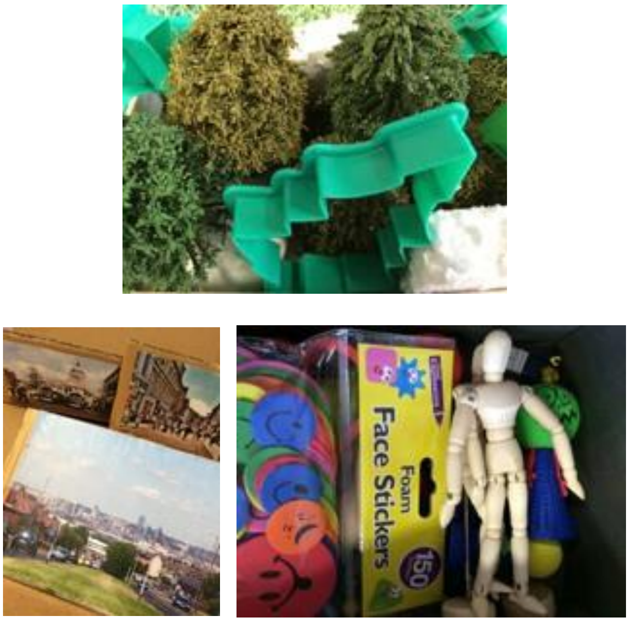

Figure 2 Trees, place cards and figures in the service design toolkit developed with adult mental health service users at Mind.

In both contexts (special needs at Oakfield, and adult mental health at Mind), pairs and triads formed quickly around the artefacts of the service design toolkit; they became props (Sanders et al 2010) available to spontaneous individual systems of meaning making, dynamically signifying a range of actions, objects and experiences. In one incident with a female participant at Mind, a slow start with the tools seemed due to a lack of exact counterparts for what she wanted to recall about her journey that day; images and characters were different scales and seemed to take on different levels of importance; some of the character pieces had strange, exaggerated facial expressions that the researcher (the first author in this case) found difficult - she had to consciously bracket her own negative feelings to allow the participant to work with whatever became useful to her in creating her own narrative; however, after a short time, the participant shifted from looking for literal representations to using what was available in a more metaphorical way. She accomplished this in conversation with the first author, so the meaning of these artefacts was shared - they communicated effectively the 40-minute walk she makes twice a week to get to Mind from her apartment. The relationship between the researchers/facilitators and the participants is therefore crucial to support in the design of the toolkit. Multiples of common artefacts are needed so that small teams can work effectively and safely without the need to negotiate shared use of popular items, which for this group can be potentially stressful.

In the first week of the service design workshop at Mind, two of the participants also chose to leave after a short time, aware of their own stress levels in a busy room with new people.

While participants in this sector will almost certainly be dealing with unknown external factors that affect their experience, there are certain aspects of the toolkit and its context of use that may contribute to incidents such as this. IDEO point out the need to consider room layout so that people have the space to move around freely, access resources and refreshments, and use the wall and table spaces creatively (2016). At Mind, we had use of a communal space with a small kitchen area at one end, which the participants were familiar with from other drop-in activities. In working with e-textiles in the first phase of the project, we had already found the space quite constrained, as the ratio of participants to facilitators was almost 1:1. In this second Service Design phase, the physical scale and materiality of the toolkit components had a negative impact on participant experience. The cardboard boxes holding the various props took up valuable space, and some individuals even found the sound of them in that space disconcerting. Participants found it hard to reach what they needed, or to see what was available to them. In addition, there is an implicit expectation in these toolkits that people will be able to work in small groups of 4 or 5, rather than the safer pairings that had developed in phase one. To work confidently with other people is a significant achievement for many mental health service users and should be seen as a potential outcome rather than a starting point for service design activity in this sector.

4. Pragmatic findings and flights of fancy in person-centred research

The personal accounts of journeys taken to Mind have varied. In some cases, the route has both negative and positive touchpoints, and these can depend on the time of year and the time of day (eg school finishing time); they are approached pragmatically by the individual, who knows what to expect and who is therefore able to cope emotionally: "that's me feeling frustrated [laughing]" (figure 3). Others are routes that have been to some extent engineered as alternatives to more stressful ones involving previous traumatic incidents: "I would never ever go that way".

Figure 3 Elaine's frustrated figure at a busy crossing.

On the other hand, ‘flights of fancy’ are an acceptable component of participation in the Person-Centred research framework (Wilkins 2010), and they were noticeable in interactions where individuals felt comfortable with each other. Where the toolkit was used to imagine future scenarios at Oakfield, responses included the fantastical as well as the familiar: “I want to fly in a hot air balloon”.

As researchers we may also find such fantastical comments occurring with other participant populations; it has been suggested that imagining near-future technologically enabled scenarios in ones own life is sometimes more challenging than taking on the role of designer and transposing to someone else’s (with apparently more easily identified ‘needs’). ‘Fanciful’ was one of four notional lifeworlds identified in an analysis of a female friendship group’s responses to a novel suite of networked digital jewellery, along with ‘immediate scenarios’, ‘own lifeworld’ and ‘other people’s worlds’ (Kettley and Smyth 2006). As in that project, individuals here mixed the everyday or ‘own lifeworld’ with the fanciful in imagining uses and experiences: “is breakfast ready for you when you come downstairs?” Where participants in the Internet of Soft Things workshops have indicated possible uses for other people’s lifeworlds, those people have often been sitting right beside them, and there is an established supportive relationship (figure 4). When figuring future things for their own lifeworlds, participants tended to include details about which music should play as output, or what form and colour the object should assume; in contrast, when imagining premises for use for others, helpful and assistive functions have been emphasised. Carers started to talk about the range of different response teams who could be involved under different circumstances, although this will need a further workshop to develop fully. In some cases, then, it is important when opening up the options for individuals that we do not then try to ‘boil down’ their responses to a generalisable outcome – E’s premises for her own use developed when she wore a sweater with tassels, and she began to relate very specific textile qualities to the possible forms for an e-textile interface for her own lifeworld. In this case, the tangibility of the prop available to the participant directly informed their understanding of opportunities with the future technology.

Figure 4   E and C.

With reference to this point, much of the feedback from both the e-textile and service design workshops has been concerned with the experience of creative entanglement being as important as the designed outcome; it may be that for some markets and users, the co-creation of the convivial design tools is as important as the participatory design of the final service and product concepts.

We found that participants at Oakfield were generally happy to use what was given in the toolkit, while at Mind, the feedback concerned the need for completely blank cards, which could become any type of item as needed. At Oakfield, the e- textiles were included as elements in the kit (figure 5); at Mind, the new group of participants has been reintroduced (or introduced for the first time) to the concept of e- textiles, in addition to working through their journey narratives with the service design kit.

Figure 5 e-textiles at Oakfield; a soft switch made by the researchers and taken to the school as creative props.

The next set of workshops will attempt to integrate these experientially. Walks designed as part of the forthcoming workshops are intended to support further discussion on the networks of soft things as part of individuals' own lifeworlds, and approach the ambitions of research 'in-the-wild' (difficult otherwise with mental health service users).

While our interest in the nature of tangibility of the e-textiles and service design toolkit, and the subsequent availability of these near-future technologies to participants' own lifeworld imaginaries continues, another aspect of tangibility is emerging from working with mental health service users. The next section reflects on the project's concerns with the representation of participants' experiences and our making of them available to wider research audiences as 'evidence'.

5. Making the person tangible in design research with mental health

As part of the participatory design approach, we collected audio-visual data of workshops in which the two communities learnt about e-textiles and the technosocial imaginary of the Internet of Things (IoT). The aim of these workshops was to open up the social imaginary to allow active participation in it. We soon noticed in transcribing the sessions with mental health service users, that the individual was often obscured or even absent, although we had personal experience of interacting with them in the workshops, and indeed with their full 'presence' in the moment. This was more so for the mental health participants than the special needs participants, suggesting that while it is a received wisdom that mental health issues may be physically 'invisible', they may also remain invisible in standard research processes, in which speech and text are paramount. In response, we decided to add an extra session to the six weeks in the first e-textile phase of the project at Mind, in which participants would have the opportunity to reflect together, or with their now familiar research facilitators, on the experiences of having taken part. We also prepared to make individual video interviews, and three participants agreed to take part in this process. These participants gave permission for their first names to be used in relation to their films, so we also refer to them here by their real names: Chris, Elaine and Meg. The final moving image outcome can be seen hosted online by participatory arts charity, Salamanda Tandem (Jones and Fielding 2015). The film was developed by Isabel Jones, creative director of Salamanda Tandem, who has 25 years of experience in developing person-centred approaches to co-creativity and film-making. Levels of consent for the film were discussed with participants so that informed consent became personalised: 'you can video and/or audio record me' or 'you can show still images of my hands/face/whole body' or 'you can show my words as text'. These decisions were respected, and we did not seek to influence them, even if this had a significant impact on the content of the film. We set aside our artistic preferences and personal agendas, in order to maintain trust and empathic understanding of the participants. Of three people who took part:

- One agreed to audio and visual recording of whole body
- One agreed to audio and visual recording of hands
- One agreed to visual recording and still images of hands and for words to be used as text

At the recording we tried to create a supportive environment, by filming in the same geographical location as the workshops, although in a smaller, more cosy room upstairs, and with facilitators and Mind staff present to offer prompts and support where necessary. The initial film, photography and audio recording sessions, took approx.1hr 15mins for each participant. Key to the approach in these sessions was in restraining the outcome driven processes often seen in the process of filmmaking. The use of story boarding, pre-laid down narrative structures, exact durations of the work, or even the media used were all put on one side in favour of a more participant-centred approach. For example, in one session the role of auteur / director shifts as the sound technology is handed over, which frees up one participant to use her own empathic and reflective skills to work as interviewer and sound recordist herself. In this way, and even in the flexible media used, the gathering of photographs, film clips, hand written evaluations, and audio recordings, the process becomes an extension of our co-design research, rather than purely as a post hoc evaluation of it.

The final film ‘An Internet of Soft Things: a dialogue in co-design with Mind’ duration 20 min 16 secs, (Jones and Fielding 2015) has been constructed in such a way that it might be later de-constructed into component parts and re-constructed for different audiences.

Showing this film at various dissemination events has been salutary. There are moments that make the researcher-presenters smile in recollection, while the audience sit confused: the shot of Chris’ cigarette packet in a top pocket is one of these moments, which demonstrates the limitations of the medium to communicate how significant Chris’ engagement was during the workshops. Instead of leaving up to ten times in three hours, he would typically leave once, to have a cigarette break; according both to himself, and to the staff at Mind, this was an exceptional achievement for him in managing his anxiety levels in large groups. In addition, we have found it necessary to prepare the audience before showing the films; as discussed, these have not been made with our own artistic practice in mind; on the day, individuals may be speaking indistinctly because of new medication; some are almost non-verbal, and others construct narratives in what might seem to be problematic ways because their memory has been affected by their condition. All of these we seek to preserve as far as possible, instead of editing out.

6. Future work

The second phase of workshops will complete in December 2015, with a further Future Workshop (Jungk and Müllert 1987) phase planned for January 2016, in which participants will apply their recent experience to the conceptual design of a new venue for mental health services in either Worksop (for the Bassetlaw district), or in central Nottingham, where the charity does not currently have a site. The ambition is to include policy makers and procurement processes in mental health at the local level, thereby extending the notion of entanglement and developing the concept of the participative process in mental health research (‘PPI’) from a design perspective. The tangibility of the service design toolkit will be further explored to explore how this supports or precludes positive aspects of tangibility for participants with lived experience of mental health issues. We will continue to make films with our participants where possible, and to reflect on how this is done in an ethical way, while having the desired impact on the audiences needed for research to have its intended impact at practice and policy levels.

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Wearable Sensory Devices for Children in Play Areas

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Abstract: Parents are often concerned about safety problems when children are playing alone in play areas. Using scenario analysis, this study combined with play areas' service designs to create a wearable assistance device for children, to encourage children to use these devices to ask for assistance and to solve assistance problems when children encounter danger or difficulty.

Non-participant observation, literature review, and data analysis were used to summarize problems encountered by children in play areas and analyze usage requirements of interactive assistance devices. This information served as a basis for the research and design of interactive assistance devices. Scenario analysis was used to simulate and re-enact the interactive requirements and scenarios children may encounter in play areas. At the same time, user requirements of play areas, parents, and children were compiled and service design blueprints were used to render service flow analysis of all persons involved. Finally, prototyping was used to propose design concepts.

The aim of this study is expected to reduce danger or difficulties encountered with children while playing in play areas, such as reduce children's crying, improve assistance problems encountered during playing, and serve as references for relevant follow-up studies.

Keywords: children safety while playing, children service design, children wearable

1. Introduction

As more and more indoor play areas are established in large shopping malls, they have become good places for parents to go when they are shopping with children. Parents often entrust their children to these play areas then leave the area to shop in other areas in the shopping malls. Consequently, they are not always by their children's side. However, shopping malls have a complex makeup of visitors. If parents are not by their children's side when children encounter danger or difficulty in the unfamiliar environment, their children may not be able to ask for assistance from them within a short period of time. To allow children to ask for assistance when they encounter problems or complex dangers in unfamiliar environments, digital interactive devices can be combined with the Internet of Things (IoT) to create an assistance mechanism for children while playing in play areas. This can allow children to ask for assistance from parents or staff in play areas and gradually improve children's crisis management skill for encountering problems or danger in unfamiliar environments. This can also prevent problems from deteriorating and allow parents to let their children play by themselves in play areas with a peace of mind even when parents are not by their children's side.

Since children from ages 2 to 7 have weaker logical thinking skills, they have not fully developed their environmental, spatial, object-related, and behavioural cognitions (Su & Chen, 2010). Indoor play areas contain different activity spaces, large game props, and a complex visitor population. Thus, children playing in play areas often encounter accidents, anxiety, trips and falls, and other dangers. These problems not only worry parents, but also result in children's sense of insecurity, dangerous situations, and crying. For children to have good playing experience in play areas, children must improve their crisis management abilities for when they encounter problems or danger, thereby improving their safety when playing. Children must be able to gain experiences and satisfaction from playing.

Apart from children, it is also important to identify other people in the play areas that are also involved with the assistance requesting behaviour, device requirements, factors, and solving methods of children when they encounter danger in play areas. The relationships and service requirements of these related persons in play areas must also be identified. This study planned the following steps to satisfy the service items of sensory devices:

- Observation on children's assistance requirements and service flow: Initially, 4 researchers spent a 2 weeks observing children playing in play areas. A total of 42 children between the ages of two and seven were observed. Average observation time for each child was 45 - 60 minutes. When children cried or requested assistance in the play area, their interactions with parents and staff in the play areas are recorded. Children's assistance seeking behaviour and assistance experience interacting with parents, staff around the play areas (offsite), and childcare personnel (on site) are also recorded. Then, children's age, problems encountered, people encountered, solutions, and duration were all also recorded. The collected data (from 42 observations) were categorized to analyze the primary reason children seek assistance and the people involved. In addition, parents, workers and childcare personnel who appropriately handled children's request for assistance during the observation process were interviewed. This allowed researchers to understand the solution used and the problems that the children encountered, thereby obtaining recommendations and related service requirements from parents and staff in the play areas. The objective is to determine common problems and solutions that can serve as references for the service flow design.
- Design of service flow blueprint: This study then analyzed problems encountered by children in unfamiliar playing environments, such as accidents or other dangers.

Scenario analysis was used to integrate children's assistance requirements and the role of parents/play area staff in the service system. A service flow blueprint was plan up to apply scenario analysis and the appropriate interactive device design to be use by children.

- Design of assistance sensory devices: The needed services of the prototype device and a technical plan for the sensory device were established. The prototype of children's interactive assistance device was then created, including device functions, technical specifications, method of use, and method of interaction.

2. Environment Safeties and Technology Application

Many different uncertain and dangerous factors exist in children's play areas. Research Morrongiello (2012) indicated that accidental injuries are the primary cause of children's death while injury prevention is a great improvement method. Effective designs not only can increase children's safety knowledge, it can also change children's behavior. Children can maintain a positive attitude when encountering danger, thereby reducing the risk of different dangers. Thus, prevention is perceived as the key in preventing children injuries. Giving children correct safety concepts and crisis management abilities can effectively reduce the occurrence of children's accidental injuries (Brussoni, Olsen, Pike & Sleet, 2012). In her book on the theories and practices of children's development while playing, Johnson (2003) proposed that even if adult intervention can improve children's playtime quality, adult participation must be conducted in an accurate and appropriate manner to prevent excessive intervention. This means that even though adult interventions improve children's problems, adults must also remember children's perspective on facility usage. Since many safety concerns and problems exist in play areas for young children, more friendly responding methods are needed to improve the existing situation. This is especially true for children encountering danger in play areas and needing to ask for assistance from others. Allowing children to have a superb interactive experience and response ability can improve the safety of children in play areas.

Some research studied children's concepts and moral sentiments; they indicated that children could understand the emotional feeling of those around them. They can feel the changes in the environment around them and sense the messages provided by adults (Arsenio, Gold, & Adams, 2006; Keller, Gummerum, Wang, & Lindsey, 2004). We discovered that children's response ability could be improved when they have a good experience and interaction with the environment.

In today's digitized society, the threshold for children to use digitized tools has lowered. Observations of children using digital products show that children's digital device usage experiences are different from the past. For example, when digital picture frames, laptops, or televisions are placed in front of them, they will intuitively feel that the screens have touch control function (Weinschenk, 2011). This shows that the current popularity of interactive devices has forced digital products and interactive models to evolve continuously and integrate. App developers need to change their design thinking, which has focused primarily on computer usage scenarios in the past, and begin to widely utilize other methods to redesign overall interactive devices. This is especially important after integrating diversified applications and services to the mobile network (Lee, 2010). As device designs, such as wireless networks and cloud services, rapidly evolve, the provision of new interactive models and good experience-and-service plans have become extremely important.

Many companies have already integrated cloud network technology with Bluetooth, infrared, NFC, and RFID wireless communication technology to provide users with new experiences. Some examples include dangerous machines making warning sounds when people are approaching, remote devices displaying light and sound, vibrating devices that indicate when meals are ready, and smart mobile devices showing the location of the user. These developments have allowed interactive devices to rapidly evolve, thereby making interactive devices more convenient for users to use. These are all related applications that can be used to improve child safety.

In this study, we use the Pandora Baby child safety mobile phone[1] as an example. Supporting both iOS and Android mobile phone systems, this mobile phone allows parents to manage children’s telephone using an app, track children using GPS, and provide SOS care functions, which automatically sends messages, calls, and transmits location information from the children’s phone to their family. This phone can also be combined with multifunctional wearable devices.

As a result of the development of wearable technologies, interaction with wearable interactive devices is also being updated continuously. The current exterior design, size, and command operation of various wearable devices are also lighter and more convenient than before. Rhodes (1997) proposed the following characteristics for wearable devices: portable while operational, hands-free use, sensors, proactive, and “always on, always running.” The lightness and convenience of wearable devices make them suitable devices for children in play areas, where they are highly active.

However, the design of these devices must have their own special features to sufficiently attract children to participate and try them (Chang, 2010). In addition to sufficiently understanding children’s requirements and attracting them to use the device, the design must also consider relevant interactive functions and the requirements of different sites to be able to satisfy the users (Hsu, 2000). Chao (2009) asserted that designers must develop products according to users’ requirements and product functions. The design of usage and operation should be considered from the perspective of various disciplines to improve product usability. Since these wearable devices are designed for children, they can include many different usages. These types of wearable devices often come in the form of bracelets, watches, remote controlled car controllers, or elevator sensors. According to different functions, weights, prices, and exterior appearances, different usage may be available,

[1] PandoraBaby child safety mobile phone：http://24h.pchome.com.tw/prod/DGAS0H-A81311765

change depending on different usage requirements. A different usage is available for different sites.

3. Methodology

This study was divided into three stages of research: non-participant observation, prototype design, and scenario story analysis. First, children's experience in playing and assistance seeking behaviour were observed and recorded. The collected data was analyzed and organized for designing a device prototype. Emphasis was placed on children's usage scenarios and the use of other assistance devices to plan the service flow of children's usage of the assistance device. The content application and prototype design was done using relevant applications and script contents, including site scenario analysis, operating procedures, human-machine interactions, and IoT technologies. Recommendations made by parents, staff, and childcare personnel obtained during the observation stage were also used in the service plan.

Stage 1: Observing Children

Before research personnel enter the play area for observations, they first prepared a child observation form and drew up the floor plan of the play area being observed. Research personnel also contacted the person responsible for the play area, discussed the content of the observation and site regulations, posted research observation announcements during the observation process, and asked the person responsible for the play area to sign a site observation agreement form.
The research announcement was posted at the entrance of the play area to notify play area customers of ongoing research observations (as shown in Fig. 1). Next, research personnel conducted observations and recorded notes on the observation forms in their hands (Fig. 2).

Figure 1: Children observation notice   *Figure 2: Research personnel conducting observations*

After observations on children playing have been completed, all the collected data and relevant literature were compiled for data analysis. Examples were given of situations and problems that children often encounter in play areas. Categorization was conducted based on children's age, problems encountered, persons who rendered assistance, and solutions.

After children solved the problem, observation personnel conducted interviews with parents, childcare personnel, or worker. The records mainly focus on what types of problems were solved, the solution involved, and what types of situation could not be solved. For example, “a girl child was found crying for unknown reasons, but she wouldn’t say anything. Bystanders and childcare personnel could not ascertain who the parents are. Since the parents were unknown, staff responsible for contacting parents could do nothing except let the girl cry until her parents came back to the play area to collect her.” The collected observation data was conceptualize and organized into analysis data. Recommendations and verbal data—provided by parents, childcare personnel, and staff—were used as references in scenario analysis planning and prototype design of the assistance sensory device.

Stage 2: Interactive Scenarios and the Service Blueprint for the Children Interactive Assistance Device

Scenario analysis charts have direct and visual features, which are helpful for understanding user experience, and enable usage of macro and micro perspectives in exploring and solving problems. Flow charts can link different objectives and requirements into a comprehensive user story (Moggridge, 2002). The “children” in the play areas were separated into a category in the service design blueprint. In the data recording and analysis process, “parents” and play area “staff” were the main contacts who solved problems for children. Play area personnel were divided into “childcare personnel”, who kept an eye on children in the play area, and “staff” responsible for controlling entry and exit, as well as contacting parents outside the play area (at the counter). Thus, children, parents, childcare personnel, and staff are the four main groups in the service design blueprint.

Of these for groups, children are the subjects of assistance and thus they are the main users of the assistance sensory device. Parents are the most important contacted subjects. Mobile devices such as mobile phones and tablets with Internet (Wi-Fi) and built-in Bluetooth functions served as connection bridges to the assistance sensory devices designed in this study. After seeking advices from play area personnel and understanding service requirements, researchers planned service blueprints for the aforementioned groups and made matches based on existing and to-be-developed devices and technology.

Stage 3: Assistance Sensory Device Concepts and Prototype Design

This stage mainly revolves around the prototype design and the research and development of the interactive device, emphasizing scenario rendering and the use of the assistance-seeking device. Scenarios were used to analysis children’s use of assistance devices. Relevant application scripts of the prototype design were also use in the design and development of the assistance device prototype. The design of children’s assistance device was combined with research data, prototype design, and Internet technology to conduct actual development. Apart from reviewing whether observation subjects and observation data are consistent, other data including video segments and additional special soft data collected during the observation process is helpful for designing the prototype.

After observing children's playing process, researchers discovered that children often used their wrists while playing in play areas. Activities such as climbing, going through tunnels, jumping around, and games can easily be stressful for their hands if an assistance sensory device is worn on the wrist. Thus, the overall prototype design considered other wearing locations such as the neck, arm, or waist. However, devices worn on the neck in a necklace fashion can vibrate heavily and may not have proper sensing ability. The proportion of children's body differs greatly, thus devices worn around the waist cannot be easily to stabilized, coming loose when children jump around. Therefore, these propositions were not used.

Devices worn on the upper arm, such as arm bands commonly seen on the market used for jogging or other sports, have superior stability, and does not swing excessively or easily come loose as a result of being squeezed. Thus, the arm design was chosen for the device. The size of the device is based on the arm width of children from ages 2 – 7, which means that the device size is controlled to be approximately 9 cm long and 6 cm wide. To be environmentally friendly and safe, polypropylene (PP) and silicone were chosen as the material. Bluetooth was utilized for position sensing and information transmission and receiving. The device has an emergency call button and LED reminder light. The device also has a rechargeable lithium battery for repeated use. Finally, the exterior of the device is designed to match the name of the play area and the theme thereof. The resulting form was a shield shape, which also symbolizes protection and safety.

4. Site Observations, Interviews and Analysis

The obtained observation data are analyzed in this section. First, the hand written contents in the observation forms were converted into text documents for follow-up study. The data collection for children of different age groups were organized and analyzed. Observation forms were coded and the data carefully categorized for analysis based on research questions, such as "what are the dangers or problems that children encounter in play areas?" "What are children's assistance-seeking behaviours in play areas and the requirements and factors involved?" "What are current solutions for problems encountered in play areas?" And, "can social behaviour and interaction between children, parents, and persons involved be improved?" After summarizing these aspects, researchers produced Table 1, which summarizes the children's age, activity area, social interaction, persons involved, assistance-seeking method, and improvement method.

Table1 Compiled observation data

Age	Activity Area	Social Interaction	Persons Involved	Assistance-Seeking Method	Improvement Method
2-3	Young children area	Parents primarily stay and care for their children	Parents, relatives, and childcare personnel	Cry or look to parents for assistance	Two-years-old children seek assistance less because parents are usually by their children's side. Some parents of three year olds will leave the play area. Often, the children cannot find the parents, but cannot solve the problem on their own, and express their frustration by crying.
4-5	Ball pit area	Accompanied by childcare personnel and other parents, relatives, or playmates	Parents, playmates, passerby, childcare personnel	Parents are usually gathered in one location or shopping in the mall. Most children have playmates. When they cry, they will seek assistance from playmates. When they cry, they will ask for assistance from childcare personnel with their playmates. Childcare personnel or adults nearby will automatically render assistance when they discover the crying child.	These children are able to find adults for assistance. However, children playing independently may not be able to explain the situation or provide parental information. They have the highest need of assistance from others.
6-7	Ball pit area	Parents are usually not present in the play area and children play freely on their own	Childcare personnel, parents	These children are more independent and can easily get into arguments or get hurt. Generally, staff will dissuade them or notify the parents.	Among these children, seizing behavior is more intense during arguments. Danger such as arguing, falling, and fighting can occur more easily. They are naughtier and do not like to follow rules. Many need to be strictly reminded or dissuaded by staff or have the parents notified.

Analysis of research observation data shows that two-year-old children are mostly accompanied by parents in the play area, who render guidance and care at the appropriate time. They have a smaller activity area and are considered a relatively safe group in the play area. Children ages 3 – 5 often cannot explain a situation that has occurred and have higher rate of assistance requirement. Because they have less mature understanding, they often cannot clearly express their needs or specifically state what occurred or their parents' names when problem occur. Generally, the play area childcare personnel will render assistance. The solution generally involves taking the child to the parents' waiting area or placating the child's emotions until the parents return to the play area for their children. For this type of situation, the child generally cannot solve the problem within a short period of time, and sometimes there are no available solutions except to wait for the parents. They will cry until their parents arrive.

Parents of children ages 6 – 7 are usually not by their children's side. These children have a larger activity area and stronger social interaction behaviour. Consequently, they encounter danger, arguments, and injuries often in play areas. These children often need guidance or dissuasion from play area childcare personnel or passerby, or have childcare personnel contact their parents. In addition, many of these children playing independently in a game area with s large number of people will often hide, secretly cry, or do not know what to do when they encounter a problem. Often, they cannot seek assistance or show that they have a problem when they first encounter a situation.

In the interview section, we interviewed 20 parents who had companied with their children in play area, and 5 staffs who worked in the play area. 6 of parents have child in 2-3 years old, eight parents have child in 4-5 years old, and another 6 have child in 6-7 years old. Overall we found out: 1. Most of parents with young children will not leave their children along in the play area, or at least one guardian would stay. They probably would read books or doing their own things alongside, but they definitely check out their child constantly. 2. Younger children stay less time in the play area, mostly about 1-2 hrs. Because younger children are easier to get tired in such energetic and noisy environment, not easy to explore the whole play area by their own, and most of adults have no patience to stay in play area for longer than two hours. 3. Children from 4-7 years old stay longer and play sharper, so they are easier to get into crying and quarrelling problems. Most of parents with older children do not stay after setting their children into the play area, they will go dinning, shopping, or hang up with friends. Children normally will stay until their parents finish their job and come to get them. 4. Staffs had hard time to comfort tearing children, mediating dispute, and contact with parents. Especially when children are crying or under depressing, they couldn't express themselves clearly, and have communication difficulties.

This is the part researchers wish to improve using assistance devices. The prototype device was designed to reduce difficulty for children seeking parents or childcare personnel and allow children to use simple methods to voluntarily contact childcare personnel and parents. That way, they will not just cry on the side, or have passerby or childcare personnel waste valuable time asking them what situation they encountered, their reason for crying, or their parents' contact information.

5. Prototype Design for the Assistance Device

Prototype design for the interactive assistance device must consider specification site requirements, service flow, and mechanism for integrating with the play area to provide appropriate usage. Parents can choose to wait outside the play area when their children go in and play, or choose to accompany their children inside. Most parents take their children inside, and then leave the play area to shop in the mall. When parents leave the play area, their children's safety is the biggest concern, followed by their children's location in the play area and the possibility of their children leaving the area on their own or leaving with a stranger. Thus, we categorized assistance devices according to usage by children, parents, and childcare personnel.

The objective is to reduce the problem of being unable to find parents or childcare personnel for assistance when children encounter danger in the play area. Bluetooth, Wi-Fi, and RFID sensors are combined with positioning, information transmission, and cloud technology to plan children's device, user and service flow (Table. 2).

Table2 Device application, application subject, and use procedures

Devices	Wearable Devices	Mobile Devices	Mobile Devices	Computer Monitoring and Control
User	Child (worn on the arm)	Parents (use Internet on mobile phones to set information on child playing)	On-site Staff (access child's contact person information)	IT personnel (information organization on computer)
Step	1. Receive a device. 2. Wear it on the arm. 3. Pair the Bluetooth ID and password. 4. Enter the play area with RFID confirmation. 5. When playtime ends, the device will vibrate and radiates a green light. 6. If it is still playtime but parents set an alarm to leave the park early, the device radiates a blue light. 7. When children press the assistance button, an assistance signal is sent and the device radiates a red light.	1. Download WebApp of the play area. 2. Register user account and password. 3. Enter member information. 4. Set the Bluetooth ID and password for the wearable device and conduct device pairing. 5. Enter information of the child in play area. 6. Set alarm for pickup. 7. View children's location (Bluetooth positioning information and map of play area) 8. Receive exit message [children leaving the entry door (RFID1), leaving the exit door (RFID2)] 9. Receive children assistance message and staff call 10. Advertisement messages (birthday discounts, VIP limited items, promotions)	1. Download WebApp of the play area. 2. Login worker account and password. 3. Set children's playing hours. 4. Access data on the children in the play area. 5. Receive assistance request signal. 6. Call and inform parents.	1. Manage member login information of the WebApp of the play area. 2. Collect member user information. 3. Receive children's Bluetooth positioning information (update database every minute). 4. Collect children's information while playing. 5. Monitor children's position (Bluetooth positioning information, map of play area). 6. Send exit messages [child leaving the entry door (RFID1), leaving the exit door (RFID2)]. 7. Receive children assistance-seeking signal. 8. Send notification messages and assign staff for assistance. 9. Notify children's parents.

Researchers observed the people from whom children seek assistance when they encounter difficulties in the play area and classified these people into four categories: children, parents, onsite staff (childcare personnel), and IT workers. Using these four categories of people, this study linked the children assistance device to parents' mobile phones, play area telephone, the play area IT system, and the Internet. A set of service flow blueprints was then devised in this study. First, when parents take their children into the play area they are asked to go to the counter to obtain an assistance device and place it on their children's arm. The parents then use their mobile phones to log in to the assistance device and pair the Bluetooth ID and password. Once the mobile device is accurately paired to the assistance device, the play area's entry and exit RFID sensor and information technology will give feedback on the child's entry into the play area. When the child leaves the play area on their own, the device will set off a sensor and immediately report the information to play area staff and the parents. The device will also have the following feedback mechanism:

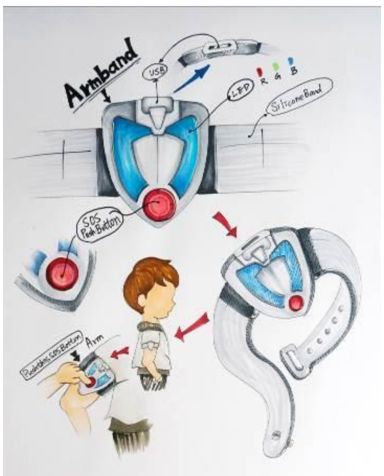
1. When the purchased playtime ends, the device will shine a green light as a reminder.

2. If playtime has not yet ended but the parents set an early pickup alarm, the device will shine blue to request the time to leave the play area.

3. When the child encounters difficulty and press the assistance button, the assistance function activates, sending out an assistance signal, and shines red light.

Different service scenarios were planned based on assistance device services, applications, different users, and usage scenarios, as shown in (Table. 3).Because children engage in significant amount of activities, a wrist worn device can cause stress on children's wrists during climbing, crawling, and playing. Thus, the device prototype was designed to worn on the arm, as commonly seen in sports to prevent the device from pressing against and producing pressure on children's wrists. Bluetooth is used to track and locate children in the play area. Built Bluetooth receivers in the play area can receive signals from the devices from multiple locations and locate the child, as well as assistance request signals from children's devices. When children encounter difficulty or danger, they can press the assistance button and the device will send out an assistance signal to receivers. This signal will be sent to the play area monitoring IT system and monitoring personnel can assigned a childcare personnel to assist. A message is simultaneously sent to the parents' mobile phone.

The overall functions of the prototype device are as follows: (1) play area safety maintenance and assistance, (2) scenarios of children requesting assistance and the relevant technology application, (3) entry time management, (4) parents' drop off and pickup time arrangement, and (5) built-in Bluetooth positioning sensor. Assistance device conceptual illustration (Fig. 3), device hardware (Fig. 4), device prototype design (Fig. 5) are as follows:



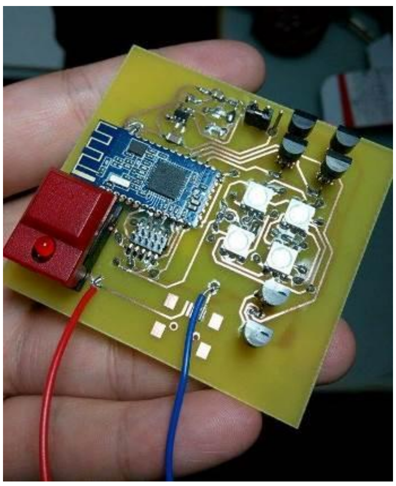
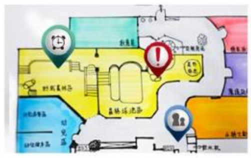
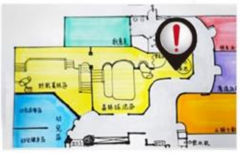
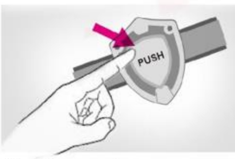



Figure 3: Assistance device conceptual illustration Figure 4: Hardware Device Figure 5: Assistance device prototype design

Table 3 Device application and use scenario

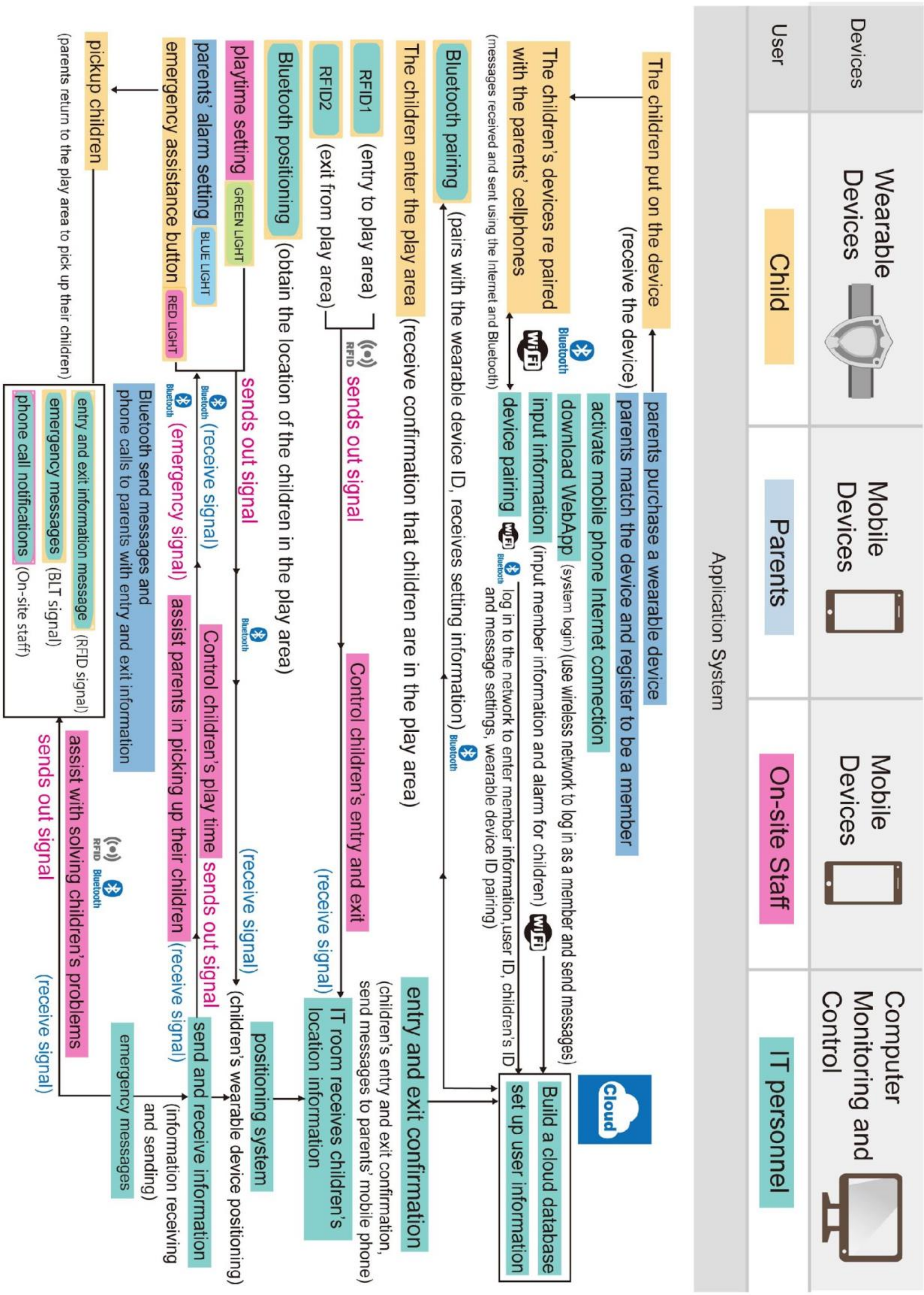
Devices	Wearable Devices	Mobile Devices	Mobile Devices	Computer Monitoring and Control
User	Child	Parents	On-site Staff	IT personnel
Usage scenarios	 (Parents purchase a wearable device)	 (Download the software and log in to the WebApp)	 (Set entry time)	 (monitor children's location on site)
	 (Parents place it on their children's arm)	 (Enter member information and pair devices)	 (Access children's device information)	 (database for message receiving and sending)
	 (If the purchased time has not yet ended, parents can set an alarm to pick up their children. The device sends out a blue light)	 (Input children information and time)	 (Sees the green light emitted from the device when purchased time is up, lead the children at the waiting area)	
	 (If the purchased time has ended, the staff takes the children to the pickup area. The device vibrates and sends out a green light)	 (Search for the children's location)	 (scan the device to access the children's information when the children are crying and cannot give parental information)	
	 (The children encounters an emergency situation and the staff renders assistance after seeing the red light)	 (Receive children's entry and exit messages)		
	 (The children counters an emergency, presses the device's assistance button, and the device sends out a red light and an assistance signal)	 (Receive emergency assistance messages and phone calls)		

The device's usage procedure and technology is shown in (Table.4).

Color code:

Child (Yellow) / parents (Blue) /On-site Staff (Red) / IT personnel (Green)

Table 4 Assistance device usage and technology system



The production of a prototype, usage scenarios, and usage system planning converted research data into concrete plans, including device deign draft, scenario analysis plan, and ways for interactive. This implemented the prototype design and functions, as well as integrated three different aspects of the plan:

23) Device Functions: This study organized the functions required by children based on data analysis, thereby allowing design of usage function and related technical descriptions.
24) Exterior Design: Since children engage in high volumes of physical activity in play areas, the exterior design of the device must be easy to carry and prevent getting lost easily.
25) Develop System and Usage: In addition to making the device usable for children inside a play area, the device must allow parents, childcare personnel, and off-site workers to help children use the assistance device. Relevant information kept in the database can be used to help the three parties contact each other easily. In the future, a sensory platform and children's information database can be developed for the assistance device. This will allow the analysis of children's usage of play area equipment, dangerous areas, and children's safety.

6. Conclusion and Suggestions

The observation of children, stakeholders' interviews, and the data analysis results obtained by this study were used as the basis for designing children's assistance device. Simulation of children's device usage and interaction in the play area was created in this study to improve children's interaction with surrounding persons. The design of the children's assistance interactive device, script, and children's use scenarios not only considered problems and difficulties encountered by children in the play area, but also used data analysis to propose specific improvements. This, combined with the methodology of service design integrated along with the requirements of systematic service process, successfully created the assistance device, proposed improvements, and helped children use the assistance devices to request help from other. The results of this study will be given to play area operators and researchers of relevant future studies as a reference.

However, in this version we are only consider the normal and correct using situations. There are two main goals we are counting to work in further study: Firstly, we are applying a wireless antenna to enhance the accuracy of the GPS locator in the device, to content the mobility and activities children have. Secondly, we are going to investigate this prototype in real environment to amended the design to fulfill the abnormal and wrong using behaviors children normally have. This can contribute to making the experience of children playing in unfamiliar environments friendlier and improve interaction and exchanges between children and other people, who can then provide assistance. At the same time, this will enable parents to track their children's movements and allow children to ensure their own safety and reduce their insecurity while they move around independently. This can build children's self-confidence and a sense of achievement while giving parents a peace of mind when their children are playing and learning independently in play areas.

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Intuitive Interaction in a Mixed Reality System

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Abstract: Tangible physical systems are more intuitive than Intangible virtual Systems. Mixed reality systems are considered as an alternative to virtual systems, bringing advantages of tangible systems into an interaction. However, past research has mainly focussed on technical aspects of incorporating pervasive-*ness* and immersive-*ness* in the virtual systems. This paper reports on an empirical study of intuitive Interaction in a Mixed Reality game system for children and the design aspects that could facilitate intuitive Interaction in such systems. A related samples Friedman's test showed that the Mixed Reality game system demonstrated more intuitive interactions than non-intuitive Interactions. A linear regression analysis further established that the variation in intuitive Interaction in the Mixed Reality system could be statistically significantly explained primarily by physical affordances offered by the Mixed Reality system and to a lesser extent by the perceived affordances in the system. Design guidelines to develop intuitive Mixed Reality systems are discussed. These guidelines should allow designers to exploit the wonders of advances in technology and at the same time allow users to directly interact with the physical real world. This will allow users to access maximal physical affordances, which are primary contributors to intuitive interaction in Tangible and Mixed Reality systems.

Keywords: Intuitive Interaction; Mixed Reality Systems; Tangibles; Child Computer Interaction

1. Introduction

Developments in hardware technologies have driven impressive technological innovations that let mobile and embedded devices connect to the Web. There is a growing need of people to be able to benefit from these technological innovations and at the same time be able to interact with the real world through tangible systems.

Children start interacting with tangibles very early in their childhood. Tangibles help children develop their sensory capabilities and put them in control of their learning process, enabling them to learn through personal investigation and exploration (Montessori, 2013). But children are also familiar with modern technology due to increasing everyday use of technology for learning at schools (Walden, 2015) and to play games (Danby, Davidson, Theobald, Houen, & Thorpe, 2015). Children are expected to use their past experience and knowledge to play in the virtual space and physical and tangible properties of the real world in the physical space of the Mixed Reality system. Tangibles are more intuitive than the intangible virtual elements (Desai, Blackler, & Popovic, 2015). The coupling between the virtual and physical domains could pose challenges in traversing the boundary between the two domains in Mixed Reality system. The question then arises how designers ensure that mixed reality systems still maintain the intuitiveness of tangible systems.

This research study is an empirical investigation into intuitive interaction in a Mixed Reality game system and design aspects that could facilitate intuitive interaction in a Mixed Reality system.

2. Background

A Mixed reality system is a user interface where tangible physical elements and intangible virtual elements co-exist in the same environment. Milgram and Kishino (1994) defined Mixed Reality as being anywhere between the real and virtual environments on the Real-Virtual (RV) continuum. The RV continuum can be adapted to discuss Mixed Reality systems in terms of tangibility and physicality of the system and the source of prior knowledge in interaction with the system (Figure 1).

At the extreme left end of the continuum (shown in Figure 1) lie tangible systems representing physical real world associated with interaction using embodied knowledge of the world, also known as sensori-motor knowledge (Alethea Blackler, Popovic, & Mahar, 2010; Desai et al., 2015). The intangible systems on the other hand lie at the extreme right end of the continuum representing virtual systems, associated with interaction using experiential knowledge (Desai et al., 2015).

Over the years, designers saw the need to develop systems that allow users to take advantage of the technological innovations but at the same time directly interact with the physical world. The real physical world is either augmented with virtual objects as in Augmented Reality (Azuma et al., 2001) or the virtual world is augmented with real physical objects as in Augmented Virtuality (Regenbrecht et al., 2004). The entire paradigm extending from the tangible to intangible systems is referred to as Mixed Reality Systems.

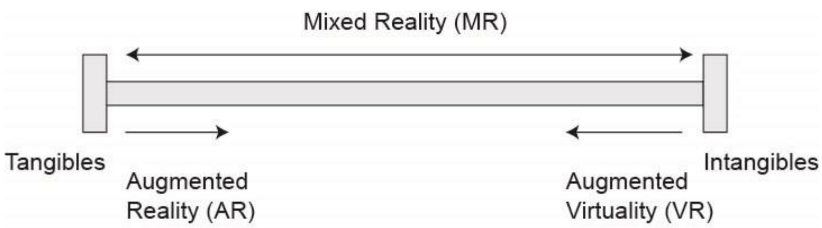

Figure 1 Continuum of Tangible and Intangible Systems (adapted from Milgram and Kishino (1994))

Mixed Reality systems have found their applications in gaming (Crowle, Boniface, Poussard, & Asteriadis, 2014), patient rehabilitation (Vogiatzaki, Gravezas, & Solutions, 2013), visualization of data (Marks, Estevez, & Connor, 2014), collaborative coordination in time critical situations (Fischer et al., 2014) and in Education (Gardner & Elliott, 2014). Efforts to develop Mixed Reality systems for children are more prevalent in Education and to some extent in gaming, than in any other field. In one of the first examples of attempts to encourage social interactions in a game, Brederode et al., (2005) developed *pOwerball* to bring together children with and without learning disabilities to play a game. The game consists of tangible objects that are manipulated on a tabletop to control graphic virtual elements on the tabletop.

Lindgren and Johnson-Glenberg (2013) studied Mixed Reality systems to facilitate embodied and immersive learning in children and developed *Meteor*, an interactive system that allows children to use their body movements to learn about how objects move in space.

Mixed physical virtual environments in a system could affect the intuitive-*ness* of the tangible physical environment and thus the Mixed Reality system as a whole. Desai et al. (2015) made an empirical comparison of tangibles and intangibles for intuitive interaction in children and concluded that tangibles are more intuitive than intangibles. They discussed the intuitive interaction in tangibles being the result of children using their sensorimotor knowledge to interact with the tangible system. Intuitive interaction in tangibles is less complex and the encoding and retrieval of associated sensorimotor knowledge is fast. On the other hand, we found that intuitive interaction in Intangibles relies primarily on perceived affordances, derived from prior experience with similar products and features. Intuitive interaction in intangibles is highly complex and the encoding and retrieval of associated experiential knowledge is slow.

Mixed reality systems can pose challenges for children as they are interacting with two interfaces which require knowledge from two different domains. The tendency in the past has been to look at Mixed Reality systems through the lens of pervasive*ness* (Fischer et al., 2014; Gardner & Elliott, 2014; Ricci, Piunti, Tummolini, & Castelfranchi, 2015). Thus the focus has been more on the technical aspects rather than human centred aspects of design. Attempts have been made to create immersive environments in virtual environments such as in *Capture the Flag* social gaming environment (Cheok, Sreekumar, Lei, & Thang, 2006) and *Holodeck,* a Virtual Reality system for visualisation of scientific data (Marks et al., 2014), instead of maintaining the natural immersive and intuitive capabilities of the physical environment. These systems are mostly based on visual perception using visual systems such as Head Mounted Displays (HMD) and Cave Automatic Virtual Environment (CAVE) which could have some impact on the immersive-*ness* and intuitive-*ness* of the Mixed Reality systems.

There is no research that looks into intuitive interaction of Mixed Reality systems and aspects that could facilitate intuitive interaction. This is important because in an attempt to allow children to exploit the wonders of technological innovations, designers may end up developing systems that are non-intuitive. This brings with it problems associated with non-intuitive systems such as difficulty in learning which can easily lead to disengagement from the product.

This research study has thus investigated intuitive interaction in a Mixed Reality game system with children. Intuitive interaction in tangible physical systems is a result of children using their sensorimotor knowledge and physical affordances offered by the system and intuitive interaction in Intangibles relies primarily on perceived affordances. This study thus studied physical affordances and perceived affordances as design aspects that could contribute to intuitive interaction in Mixed Reality systems.

3. Methodology

An observational study was carried out within People and Systems Lab (PASLab) at Queensland University of Technology (QUT), Brisbane, Australia. Children participated in the study during school holidays. They were asked to bring along a friend or a sibling to play with. The children and their parents were known to the researchers through personal contacts and through their participation in a previous research study.

42 children in the age groups of 5 to 12 years participated in the study. Twenty-one pairs of children were observed playing with a Mixed Reality game system from Tangible Play called Osmo (Figure 2). Osmo allows physical play with a virtual system (IPad). It comes with a reflector and a stand that is attached to an Ipad and four games that can be downloaded as apps from iTunes. The app used for the study is called 'Newton'. Newton works with any objects or drawings that are placed in front of the screen and manipulated to guide falling balls onto targets (Figure 2). The game involves manipulating objects and drawings placed in front of the screen to guide free falling balls onto various targets on the screen. The physical interaction in the game is entirely with the objects in real space and in the context of achieving the goal of directing balls onto the targets. The display screen is used for generating feedback from the manipulation, in relation to the targets on the screen.

Figure 2 Osmo setup and Newton app.

Children were instructed how to play with the game system and told that they have to work together as a team. The entire game play was video and audio recorded for analysis. Two digital video cameras were used to record the activity (Figure 3). One camera was placed in front of the children and the other on the side to capture the interaction and facial expressions during the playtime.

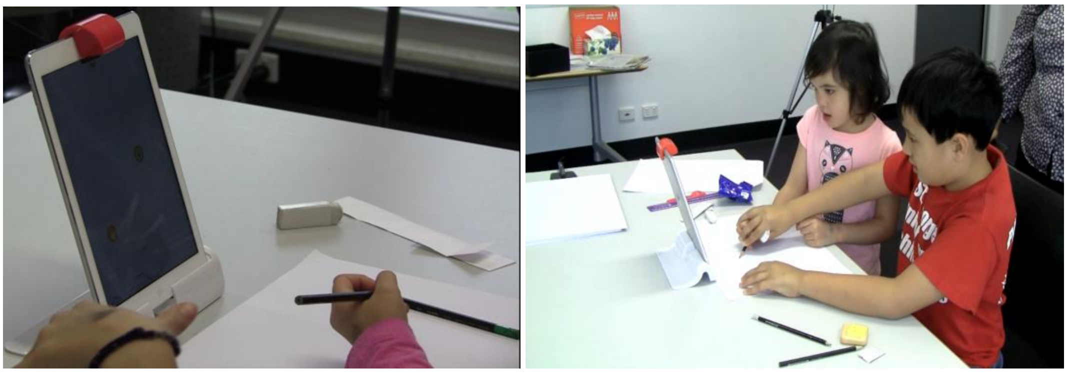

Figure 3 Children playing Osmo. The view of the tablet screen (on the left) and the view of children manipulating objects and drawing in the physical space (on the right)

4. Analysis

Audio-video recordings of the game play were coded using Noldus Observer XT 12 to analyse the interaction with the game system. The interaction with the game system was categorised into two main behaviours: Explore and Perform. Explore refers to a behaviour where children were figuring out ways to guide the balls onto the target. They manipulated objects and drawings in front of the tablet, exploring different angles and layouts to guide the balls onto the target. Once they had found the right alignment and layout, they made few adjustments to their angular positions to guide the balls onto the target. This behaviour was coded as Perform.

Explore and Perform behaviours were coded for Type of interaction: intuitive, non-intuitive and partially-intuitive and Type of affordance: physical and perceived affordance for each child. Figure 4 shows a part of the coding in Noldus Observer XT 12.

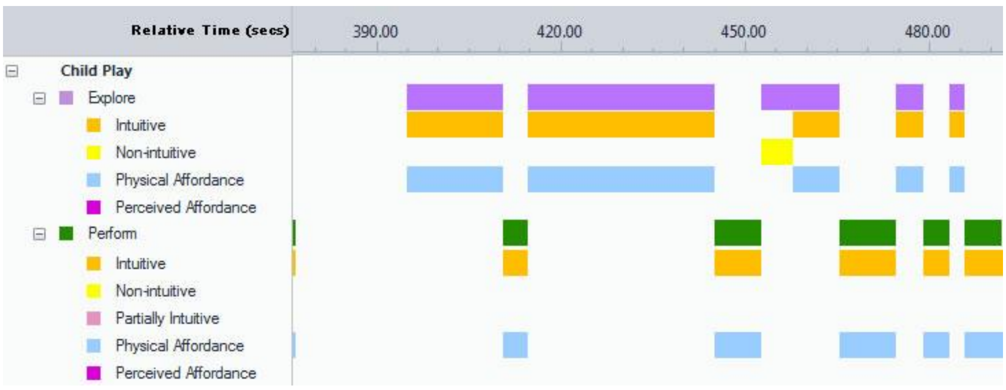

Figure 4 Part of a coding of the game play in Noldus Observer XT 12

Coding Heuristics

Intuitive interaction involves utilising knowledge gained through other experience(s), is fast (Salk, 1983), and generally non-conscious (Bastick, 2003). The coding heuristics employed to code for intuitive interaction are derivations of methods developed by Blackler et al. (2010).

Non-conscious reasoning – Intuitive interaction does not involve conscious reasoning (Bastick, 2003) but involves actions and decisions which cannot be explained or verbalised (Alethea Blackler et al., 2010). Children were considered to be reasoning non-consciously when they could not explain how they guided the balls onto the targets. One of the participants said,

> "It is easy, don't you understand this?"

Another participant who chose to draw instead of using objects, said while playing,

> "I like to draw, drawing is easy. Do you know I got an award at the assembly for art?"

Although the participant did explain why he chose to draw, the explanation did not match his actions in the game. Such behaviour was also coded as intuitive interaction.

Degree of Certainty – Intuition is associated with high degrees of certainty, confidence and expectation with respect to correct use of a feature (Bastick, 2003; Hammond, 1993; Woolhouse & Bayne, 2000). When participants were certain and confident about their strategy to guide the balls onto the target, in contrast to trying out various options, the behaviour was coded as intuitive interaction. One participant, while playing the game, said to the other child,

> "I know. I know. I got this."

The above statement not only shows that the participant was certain and confident of her decision but also was reasoning unconsciously because she did not verbalise the actual method that she is going to follow.

Non-intuitive behaviour is associated with conscious reasoning, uncertainty, lack of confidence and unclear expectations with respect to the interaction with the system (ref). While playing one of the levels in the game where four fans have to be spun all at the same time by guiding balls onto the fans, one of the participants said,

> "Alright, we need to think about this logically".

Some children did not understand the visual cues in the app on the screen such as a teleporter; they patted their hand on their forehead indicating confusion and said,

> "What does this mean?"

When interactions showed signs of intuitive as well as non-intuitive interaction, they were coded as partially-intuitive. For example, a child noticed that the balls were escaping towards the left of the screen instead of being guided towards the target. He picked up a straw and puts it on the left so that balls do not escape anymore. He told the other child,

> "Hang on. I have got this! Let's put this [here] so that balls don't run away"

The child clearly verbalised his behaviour (non-intuitive interaction) but was certain and confident about his decision (intuitive interaction).

Physical and perceived affordances were coded as per the following heuristics:

Physical affordance - Objects have spatial and material properties such as colour, texture, composition, size and shape (Hornecker, 2007). The properties of the objects offer a potential use to the user (Maier & Fadel, 2009). People perceive their interaction with these objects by discriminating their properties (Gibson, 1979) and using their sensori-motor knowledge that is derived early in childhood.

Children used spatial orientation of objects and drawings relative to the balls and targets on the screen to decide on the optimum angular position to guide the balls onto the targets. Children aligned pencils and straws at horizontally when the targets were aligned horizontally. When the targets were not aligned horizontally, the objects were aligned at an angle with each other. The properties of the objects do not mean anything in itself, but in relation with other objects in the physical space and elements in the virtual space, children were able to derive appropriate sensori-motor knowledge to align the objects to guide the balls onto the targets (Stoffregen & Mantel, 2015). Hornecker (2007) refers to this relationship as spatial relationship. When children used this spatial relationship to guide the balls onto the targets, the interactions were coded as physical affordance.

Perceived affordance – Perceived affordance is based on past experience and prior knowledge (Blackler et al., 2010; Norman, 2004). People look for clues in the interface to apply their previous knowledge (Dotov, Nie, & De Wit, 2012). These clues could be incidental/natural, for example weight of a bag, or deliberate, for example a scrollbar in a web explorer. The weight of the bag provides a natural clue whether it will be easily carried by the user, without even weighing the bag. In absence of natural clues (physical affordance), children resort to deliberate clues. The scrollbar not only tells users that they can navigate through the web page by sliding the scrollbar but also tells them how much they have read and how much is still left to read. The scrollbar acts like a virtual book mark to the web page. Children perceive such clues using their past experience and knowledge.

The Mixed Reality game system offered familiarity and a set of common metaphors to leverage users' familiarity in interaction. Children used their experience in everyday life and their knowledge about features of tangible objects such as mass, elasticity, rigidity, mobility, etc. One of the children explained his technique of trying to hit the balls with a straw:

> "…This is like tennis..."

Some children referred to the simulation of balls hitting a bowl on the screen resulting in a ball emerging from another bowl as a teleporter. One child explained that he had read about it in the book, 'Charlie and the Chocolate Factory'. Interactions where children used their past experience and knowledge to play with the Mixed Reality game system were coded as perceived affordance.

The audio and video data was coded with caution; every observation was checked twice and at times thrice. All coding was done by one researcher and to avoid observer bias, data were coded twice with a break of 15 days in between each coding. Reliability analysis was carried out in Observer XT 12 to determine if there was an agreement between the two sessions of coding carried out by the researcher. Cohen's kappa (κ) is a measure of agreement between two sets of coding. Cohen's kappa (κ) statistic can range from -1 to +1 and was found to be 0.92. Based on the guidelines from Altman, (1990), a kappa (κ) of 0.92 represents a strong strength of agreement between two sessions of coding. Furthermore, since p = .00, kappa (κ) coefficient is statistically significantly different from zero.

5. Results

The coded data were exported from Observer and then analysed quantitatively using SPSS statistics tool. The objective was to generate reliable generalisable population-based results that are suited to establishing cause-and-effect relationships. Future exploratory and investigative qualitative research will specifically look into these relationships.

5.1 Intuitive Interaction in Mixed Reality Game System

The first part of the analysis was to investigate intuitive interaction in the Mixed Reality game System. The boxplot shown in Figure 3 compares the numbers of intuitive, non-intuitive and partially-intuitive interactions in the Mixed Reality system.

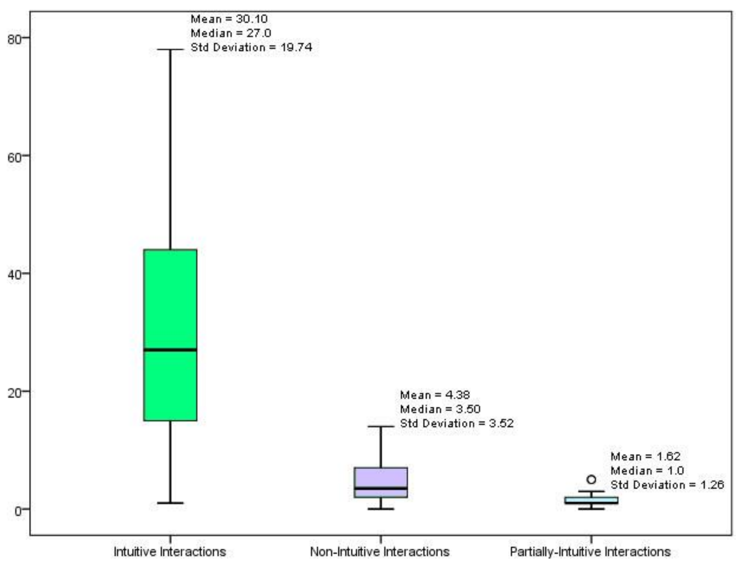

Figure 3 Number of intuitive interactions, non-intuitive interactions and partially-intuitive interactions in a Mixed Reality System

The Mixed Reality game system demonstrated highest number of intuitive interactions followed by non-intuitive interactions. Partially-intuitive interactions were the least demonstrated.

A related Samples Friedman test was run to determine if there were any statistically significant differences between *numbers of intuitive, non-intuitive interactions* and *partially-*

intuitive interactions in children playing with the Mixed Reality game system. The Friedman test works by ranking each score of the dependent variables (*numbers of intuitive, non-intuitive* and *partially-intuitive interactions*), according to its value, with the smallest rank assigned to the smallest value. The ranks obtained for each of the dependent variables are averaged separately.

The mean ranks obtained for each of the dependent variables and a histogram of rank values of *numbers of intuitive interactions*, *non-intuitive interactions* and *partially-intuitive interactions* is presented in Figure 4. If the shape of the rank distributions is similar, which is the null hypothesis of the Friedman test, the mean rank will be the same for all three types of interactions. However, intuitive interaction has higher mean rank than non-intuitive and partially-intuitive interaction. It is this difference in mean rank that is tested by Friedman test for statistical significance.

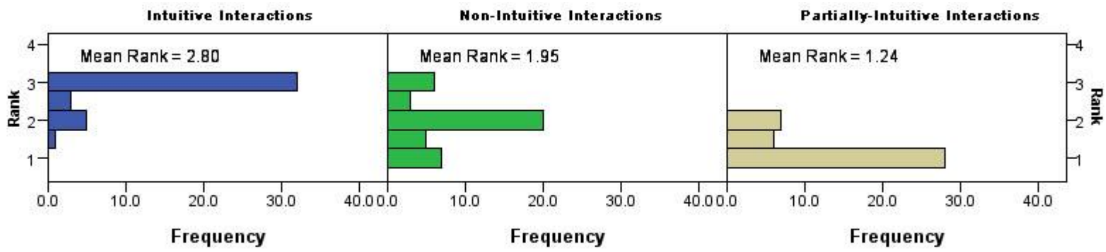

Figure 4 Rank distributions of number of intuitive, non-intuitive and Partially intuitive interactions in Mixed Reality game system.

The rank distributions of *numbers of intuitive interactions, non-intuitive interactions* and *partially-intuitive interactions* were not similar, indicating statistically significant difference in the type of interactions, $\chi^2(2) = 62.69$, $p < 0.05$.

5.2 Affordances in the Mixed Reality game system

The intuitive interaction in the Mixed Reality System was further analysed by studying the affordances offered by the game system to facilitate intuitive interaction. A Multiple regression was run to explain how much of the variation in intuitive interaction in the Mixed Reality system can be explained by physical affordances and perceived affordances in the Mixed Reality system. Regression analysis investigates relationships between variables. In contrast to methods such as the Friedman test which indicate if a significant difference exists between the variables, regression analysis determines if physical affordance and perceived affordance influenced intuitive interaction.

Physical and perceived affordances statistically significantly explained 82.5% of variability in intuitive interaction in the Mixed Reality system, $F(2,39) = 95.195$, $p<0.05$. This suggests that the regression model is a good fit of the data. Comparing the relative contributions of physical and perceived affordance to the intuitive interaction of the system (Figure 5), it was found that physical affordance explained 71.9% of the variability in the intuitive interaction as compared to Perceived affordance contributing to 28.2% of the variability.

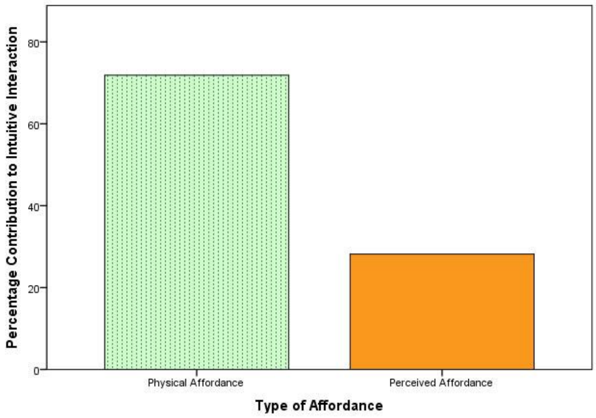

Figure 5 Relative contributions of physical and perceived affordance to the intuitive interaction of the system.

6. Discussion

The results have shown that the Mixed Reality game system demonstrated statistically significantly higher numbers of intuitive interactions as compared to non-intuitive and partially intuitive interactions. Further study into the role of physical affordances and perceived affordances in the intuitive interaction of the Mixed Reality game system also revealed that physical affordances offered by the elements of the game system are the prime contributors of intuitive interaction with the Mixed Reality system.

One of the advantages of direct interaction with objects is that the coupling between cause and effect is quickly observed and its spatial position in space quickly changed if required (Rogers, Scaife, Gabrielli, Smith, & Harris, 2002). Children were given an option to either draw or use objects to guide the balls onto the targets on the tablet screen. Some children chose to draw while others preferred to use objects. Some children preferred to draw, but slowly moved on to using objects. This could be because drawing involved erasing number of times before the right alignment was reached. On the other hand, objects required a quick change (cause) in angular position when the balls were missing the target (effect).

Children were able to play intuitively because of the physical affordance offered by the spatial properties of the objects that could be easily manipulated to obtain the correct angular position to achieve the goal of guiding balls onto the target. Children picked long elongated objects such as pencils and straw and drew straight lines to guide the balls onto the targets. Children picked short cardboard strips or an eraser where small deflections were required. While playing levels with multiple targets, children aligned the objects at an angle when the targets were at an angle while they kept the objects horizontal when the targets were placed horizontally.

Perceived affordance also contributed to the intuitive interaction in the Mixed Reality game system. Some children used their past experience and previous knowledge to interpret the meaning of the elements and cues in the app. The spherical virtual objects were intuitively recognised by children as targets. When coloured targets were introduced in the game in one of the levels, children were quick to match the coloured balls onto the same coloured targets. Some children drew tunnels around the target and the gun that released the balls.

It is necessary to look at the contributors of non-intuitive interactions in the game system along with the contributors of the intuitive interaction as it allows designers to come up with design guidelines to develop future intuitive Mixed Reality Systems. Some of the virtual elements in the app either went unnoticed or the children were unable to interpret the meaning of the virtual elements contributing to non-intuitive interactions. Spinning a fan by guiding balls onto it, a teleporter in the form of paired bowls and an accelerator in the form of a flashing arrow could not be reasoned and understood by the children. The meaning of the virtual objects had to be either explained to the children or they consciously tried to reason it out.

The other cause of non-intuitive interaction was the coupling between the tangible physical and intangible virtual space. They used their previous experience interacting with tablets and virtual systems. Some children started playing the game by swiping on the tablet trying to guide the balls onto the target before realising that the game is controlled through manipulations in the physical space. Children often could not determine the boundaries in the physical space in relation to the virtual space. Some children were unable to understand the disappearance of objects from the virtual space when they moved the objects outside the field of view of the camera, resulting in non-intuitive interactions. Some children used objects in mid-air to strike the balls onto the target, as one child said, *"I know this game, I have played this on Xbox"*. The objects, being too close to the camera, were outside the field of view of the camera and thus these manipulations were not detected in the virtual space. Similar boundary crossings were observed in the horizontal plane, on the left and right of the tablet screen.

However, once Children had figured out the boundary limits of the physical space in relation to the virtual space, they were able to continue playing the game intuitively. One child drew lines on the paper to indicate the boundary limits for moving the objects in the physical space and others were able to able to move the objects back within the limits without prompts. The interpretation of the virtual objects in the virtual space and the coupling between the physical and virtual spaces were the main contributors of non-intuitive interaction in Mixed Reality systems. However, the intuitive interactions in the game system were higher than the non-intuitive interactions, highlighting the importance of physical manipulation of objects in real time and real space in facilitating intuitive interaction in Mixed Reality Systems.

6.1 Implications in Design

The mixed reality game system, Osmo consists of a tangible physical space that allows direct interaction and manipulation with physical objects and an intangible virtual space with virtual elements. Intuitive interaction in the Mixed Reality Systems was predominantly due to physical affordances offered by the spatial orientation of the physical objects in the physical space in relation to the virtual elements in the virtual space.

non-intuitive interaction in the mixed reality game system is predominantly due to the virtual elements, the meanings of which were not understood by the children and the challenges posed by the coupling between the physical and virtual spaces. Children spent some time learning about the virtual elements and the boundary issues before they started playing intuitively.

Although the Mixed Reality game system demonstrated non-intuitive interactions due to above mentioned issues, there were higher numbers of intuitive interactions than non-intuitive interactions in the game system primarily due to the physical affordances offered by the direct interaction and manipulation of the objects in the physical space. This is in line with Blackler's (2008) continuum of intuitive interaction, according to which the simplest form of intuitive interaction is through physical affordance which is derived from sensorimotor knowledge. Encoding and retrieval of sensorimotor knowledge is fast and it is acquired very early in childhood. Population stereotypes (such as clockwise to increase or red for stop) is the second most accessible form of intuitive use followed by perceived affordances. The higher end of the continuum contributes to high complexity in design for intuitive use (Althea Blackler, 2008) and requires maximum encoding and retrieval time.

Desai et al. (2015) compared intuitive interaction in a tangible physical system to that in an equivalent intangible virtual system using continuum of intuitive interaction. They found that intuitive interaction in physical systems is derived from sensorimotor knowledge, physical affordances offered by spatial and material features naturally inherent in the tangibles and from experiential knowledge acquired from prior experience with the physical properties of similar and other physical systems. Intuitive interaction in virtual systems relies heavily on perceived affordances, derived from prior experience with similar products and features. Intuitive interaction in virtual systems is also governed by population stereotypes associated with the technology such as tablets and touch screens are associated with swiping left, right, up and down on the screen.

Based on the discussion above on factors contributing to intuitive and non-intuitive interaction in the Mixed-Reality game system, the following design guidelines could help to insure intuitive interaction in Mixed Reality Systems:

26) **Use of physical affordances** – Intuitive interaction in tangible and Mixed Reality systems is primarily due to physical affordances. Facilitating user inputs to the system through direct interaction and manipulation of physical elements in the physical space allows users to take advantage of the physical affordances offered by the elements in the system. The virtual system provides feedback on the manipulation and interaction in the physical space.
27) **Use of perceived affordances** - The virtual elements in the virtual space should be designed keeping the past experience and prior knowledge of the users in mind. The act of spinning a virtual fan is not known to children, so cues in the form of a simulation of balls falling on a fan resulting in its spin could speed up the learning process.
28) **Dimensions of interaction** - If the virtual space is in two-dimensions, such as the tablet screen in Osmo, limiting the interactions and manipulations in the physical space in two-

dimensions, such as moving objects in the horizontal plane, help users to traverse the coupling between physical and virtual space.

29) **Size of interaction spaces** - The size of the physical space and the virtual space in a Mixed Reality System are usually not the same. This could result in physical manipulations and interactions in the physical space going out of the limits of the virtual space. The boundaries in the physical space in relation to the virtual space should be specified. For example, simple lines in the physical space outlining the boundaries in the field of view of the camera could reduce the time taken to learn about the boundaries. Alternatively, a feedback from the system to move back within the boundary limits could help train people to determine the boundaries.

These guidelines are some ways in which Mixed Reality systems could be designed for intuitive interaction and probably also for immersive interaction.

7. Conclusions and Future Research

Prior research has shown that tangibles are more intuitive than intangible systems. Mixed reality systems incorporate both tangibles and intangibles in one system. A question then arises on the intuitiveness of Mixed Reality Systems. This study has carried out an empirical investigation on intuitive interaction in a Mixed Reality game system and the aspects that facilitate intuitive interaction.

Intuitive interaction in Mixed Reality systems is primarily derived from sensorimotor knowledge and physical affordances offered by the tangibles and from prior experience with the physical properties of similar and other tangibles. The coupling between the physical and virtual space and children unable to reason with the virtual elements in the virtual space were identified as contributors to non-intuitive interaction in the system.

Some design guidelines to develop intuitive Mixed Reality systems were discussed. Further research into different configurations of Mixed Reality systems, such as body interactions and gesture-based interactions, is required to further build on the guidelines. This study is important as it investigates Mixed Reality systems from the perspective of a human centred design approach rather than from the perspective of looking at technical aspects of incorporating immersive-*ness* and pervasive-*ness* in a virtual space.

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From nano to macro: material inspiration within ubiquitous computing research

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Abstract: Technological disruption grants continuous inspiration for design innovation. In particular, current paper focuses on the emergent interaction between the fields of ubiquitous computing (U.C.) and design. The interdisciplinary character of U.C. research requires knowledge from art, design, and architecture (A.D.A.) and as such, presents opportunity for cross-fertilization and future design. Within U.C., the inquiry labelled as material turn frames a particular dialogue between nanotechnology and traditional materials. Nanotechnology opened new material avenues and has impacted methodologies of design and drives the discussion throughout this paper. In addition, the way these new technologies might address human centred design approach are considered. In sum, this paper discusses routes for disciplinary displacements of A.D.A. suggesting that these have a positive impact in the future of the practice.

Keywords: Computing, Design, Research, Interdisciplinary, Future, Materials

1. Introduction

In the 80's the dominant interaction model with computers was linked to the rise of personal computers. Mark Weiser, a chief scientist at Xerox PARC in the United States considered this interaction with computers to be complex, demanding too much attention, and isolating people. Indeed, personal computers were imposing objects on desktops and restraining people from other activities (Weiser, Gold, & Brown, 1999). Solving these issues meant to create a new vision for the interaction model.

Weiser's analysis on trends on computing in relation to humans is a starting point for reflection. The pioneer mainframe computer in the early 40's had a management model of "one computer to many people" and personal computing evolved to a one-to-one model. Finally, Weiser projects the future to be of Ubiquitous Computing (U.C.) where "one person to many computers relationship" is established. The computer for the 21st Century would be integrated within a range of environmental contexts aiming to augment, aid or complement human capacity in a most natural and unobtrusive way. Thus, technology would serve as an enhancer, instead of a disrupter of life, and the paraphernalia of peripheral devices (e.g., mouses, printers, screens) would disappear. In this future scenario computers are invisible, and the process of interaction is calm (Weiser, 1991).

2. Approaches to Ubiquitous Computation

Weiser's definition of computing centres on human beings. In fact, the concept of U.C. proposes "a very difficult integration of human factors, computer science, engineering, and social sciences" ("Ubiquitous Computing," 2015) thus getting insight from several disciplinary backgrounds. For instance, during 1988's Ubiquitous Computing program in the Computer Science Laboratory (CSL) at Xerox PARC, evaluation methods were taken from Anthropology and integrated into research. The use of participatory observation enabled researchers to perceive the radical difference between how people used technology from the way they claimed to (Weiser et al., 1999).

The incorporation of social sciences brings additional advantages to research in computation design. This is the case when acknowledging the susceptibility for "confirmation biases", that is, researchers' inability to not influence results. Thus outcomes are presented as a perspective, thus, as hybridization of point of views. Furthermore, social sciences methods consider the gap between information and hard data, while applying qualitative versus the quantitative evaluations. As Weiser stated, the point of view of social sciences was determinant to drive computing research "from atoms to culture": if the disappearance of interface is a goal of U.C., culture(s) as a value is emphasized. Therefore, culture becomes the source from which research could start from and that practice could aim to create. In this sense, design within computing contexts would ultimately achieve a human-to-human interaction instead of a human-computer one (Weiser et al., 1999).

Currently, Ubiquitous Computing research has divergent views and outcomes. For instance, the overlapping concept "internet of things" is a model that proposes to design everyday objects - such as domestic appliances - connected to the Internet. These devices range from wearables to any surface that might be embedded with electronics and sensors. The main idea is having an object-to-object communication able to sense the world that can dynamically adapt to variation without direct human intervention (Kellmereit & Obodovski, 2013).

David Rose proposes, on the other hand, an alternative version on U.C. He suggests creating "enchanted objects", i.e., "instead of having a conversation of media, having a dispersion of intelligence in several objects" (Rose, 2014). In this case a constrained degree of technology is embedded into things. Practice research stems from first i) identifying core human values and desires from which a relation to objects is noted, and ii) intensifying that relation through technological features. Technology would work like magic, looking less for efficiency than for affectivity and expressivity. The perception of technology would be a symbolic manifestation in objects coming from an imperceptible source.

Rose mapped human desires in relation to objects in six categories:

I. omniscience. the desire to know all
II. telepathy, the desire for human connection
III. safekeeping, to protect and be protected
IV. immortality, to be healthy and vital
V. teleportation, to move effortless, and
VI. expression, to create, make and play

An example of the application of this method, falling under the category of safekeeping, would be an umbrella calling attention to his owner whenever there is a rain forecast, or bottle cap on pills case outputting clues on the right time for taking medicine. Rose's proposal stems from a systematic analysis of cultural environment beforehand. This is a design method that initiates research driven by cultural values, and presents technology as open solutions and flexible. Indeed, the adaptation to different cultural contexts is prone to design critic.

The "material turn" in U.C. brings smart materials, ubiquitous computing, computational composites, interactive architectures, the internet of things, and tangible bits in relation to one another. The role that "non-computational materials" have in Human Computer Interaction (HCI) (Wiberg, Kaye, & Thomas, 2014) is simultaneously recognized. This means "making the digital real (again)" (Kitzmann, 2006), having computing and information re-imagined as just another material (Kuniavsky, 2010). As such, the material turn builds research upon the materials as defined in the arts and humanities, science, and applied science. Mainly, materials are foregrounded from interaction design, design practice and the notion of ''craft'' - traditional and ancient materials are presented as computable - further integrating ground-breaking achievements on materials with software engineering. Two approaches to this relation between new materials and crafts, are explored by Leah Buechley's in the low tech and high tech research group ("Leah Buechley," 2015), and by Catarina Mota's open materials work, which presents new materials and traditional technics, as open source (Mota, 2015), and dislocates experimentation from the research lab to a Do It Yourself (D.I.Y.) setting.

3. From nano to macro

Nanotechnology gave a definitive contribution to materials technological dialogue. The invention of the scanning tunnelling microscope (S.T.M.) at IBM Research Division by two physicists, Gerd Binnig and Heinrich Rohrer, enabled to visualize a new world of the very small. Indeed, Dr. John E. Kelly III, IBM director of research confirms that S.T.M. "opened new avenues for information technology that is still being pursued today". S.T.M. is a ground-breaking instrument able to go beyond imagining and measurement. It allows to manipulate atoms and therefore the creation of new materials stemming from the nano scale (IBM, 2015).

S.T.M. is an electron microscope that applies quantum physics to reveal the surface of matter. Simply put, readings at the quantum level are acquired by directing particles to surfaces that return a specific electronic feedback according to materials' different atomic structure. Materials are energy-matter bounding in permanent motion, and measurements reveal that these particles can have two positions at the same time, a quantum superposition of states. Quantum decoherence results from analysing the frequency on the position of particles in time, and thus determining the wavelength. Hence, matter behave both as waves and particles. The determination of the atoms' position depends on computation, and images are then created and taken from data reading. ("Tout est quantique," 2015). The microscope "observes" through data taken from a material (energy) interaction.

In fact, nano-technological materials, physics, and mechanical engineering research labs have "a direct implication on the historical processes of design"(DeLanda, 2004). The traditional paradigm of the genesis of form depends on "historical processes of homogenization and routinization that have promoted the "hylomorphic schema". Neri Oxman further adds that the modern program reinforces form (idea) over skills, and assigns to materiality a secondary role. In the context of art, design and architecture (ADA) materials are traditionally part of the discourse of a project, and not the source that serves the form (Oxman, 2010). The modern paradigm is confronted with nanotechnology and "new theories of self-organization" and "the potential complexity of behaviour of even the humbler forms of matter-energy" (DeLanda, 2004). This notion inspired Oxman's approach to making. For her in Nature's way of building "there is always a direct relation between matter and energy, between form and environment and between organ and function" (Oxman, 2010). Thus, applied quantum physics brings forward a new relation between form and structure. The enunciation between matter, energy and environment as givers of form is set ("Tout est quantique," 2015).

Consequently, it is no longer possible to define design "from the outside on an inert matter" (…) as a hierarchical command from above as in an assembly line" (DeLanda, 2004). Indeed, form "may come from within the materials" which becomes something "that we tease out of those materials as we allow them to have their say in the structures we create" (DeLanda, 2004). Therefore, applied Science has the potential to dislocate purposes and methods of design practice. When designing at a nano-scale level, materials acquire meaning while moving into the macro scale, i.e., to human scale. Designing at this new nano scale is made from the matter (atom) to the idea, therefore from the bottom-up. In fact this is a direct inversion of the top-down approach in which materiality is chosen to convey an idea, to serve a concept defined *a priori* and then imposed on materials (Figure 1).

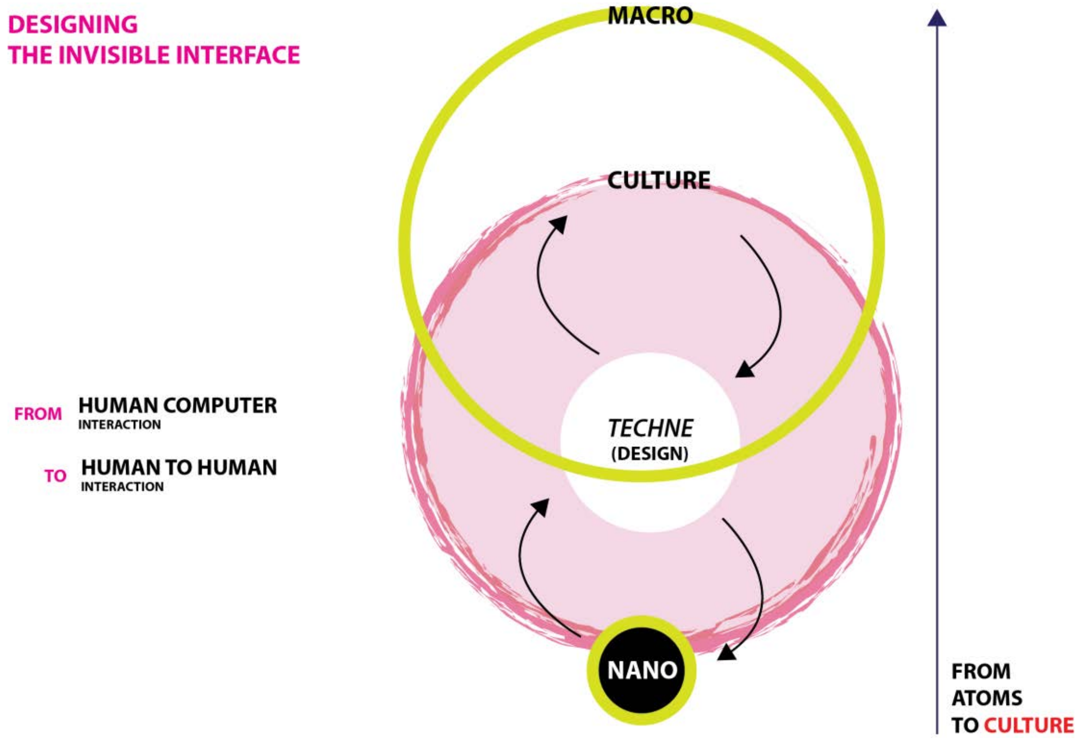

Figure 1 – Technê in context of Human-to-Human interface: research map inspired by Weiser's "Building Invisible Interfaces " (Weiser, 1994) and nanotechnology (DeLanda, 2004).

Accordingly, these considerations on matter inspired new strategies and methods in design, such as those enunciated by Oxman. For her the main point is to "copy nature's inventions" intending to design while desiring "to survive on earth", that is, for sustainability. Oxman finds inspiration in biotechnology, biomimetics and biogenesis (Oxman, 2010) which she applies to material-based design computation processes.

The materialization of these strategies has a broad expression, and only a glimpse illustration can be made on their wide range and impact, but above all, their disruptive potential. In a simplified manner, biotechnology uses living organisms to create new products. An example could be given with the use of mycelia to create bio-plastic, as applied to Lynn Rothschild's drone that is biodegradable, with all electronics components dissolving into the environment (iGEM2014, 2015). Nano-biomimecry suggests mirroring nature's witty behaviours into materials. An example of the latter is self-repairing concrete (Brownell, 2010), behaving like self-healing human skin. Indeed, biogenesis intends to create life in a laboratory. Furthermore, these bio-based methods have outgrown the science lab set, and inspired designers like Suzanne Lee who makes use of "biocouture" to grow wearable fabrics by using yeast and bacteria ("Meet The Woman," 2015).

The "material turn" proposes to tackle the division between the physical and the digital. A deeper look at this new approach to design reveals that this is a reconciliation that transcends a mere translation of the digital to physical interface. An example of the latter, can be found on Graphic User Interfaces (G.U.I.) transition into Tangible User Interfaces (T.U.I.) (Ishii & Ullmer, 1997). In the light of material turn, the initial statement on

Ubiquitous Computing proposed by Weiser, expands beyond the disciplinary delimitations of practice-led design research, but simultaneously widens the notion of the “ubiquitously of computation”: materials reveal their own computable nature and a myriad of new possibilities arise.

Hence, smart materials and computational composites are visible product outcomes from nanotechnology research labs. Manzini considered them to be “the highest expression of the paradigm of tailor-made materials” (Ferrara & Bengisu, 2014), and consolidating a “contemporary third phase of the industrial revolution”. The vast array of high-performance materials, range from changing colour, form, dimensions, temperature, to moving by themselves (Ferrara & Bengisu, 2014).

Smart materials present materiality as embedded smart systems, which resonate with what was described by U.C. typically associated to digital systems. Indeed, smart systems combine (input) sensors, a data processor, and an actuator (output), and perform a specific action. The same interaction model can be identified in a smart material: an array of stimuli triggers atomic processes, which configures a transformation as the output. Indeed, Addington and Schodeck point of view reinforce the concept of materials as systems. In their perspective “smart materials and structures are those objects that sense environmental event, process that sensory information, and then act on the environment” (Addington & Schodek, 2005b).

Considering U.C., Varadan and Smith make an important distinction between a smart system and smart materials. In fact, “smart systems do not necessarily contain smart materials, so the ones that do contain them are properly called smart material systems” (Ferrara & Bengisu, 2014). This is a fundamental difference to take into account when considering designing a U.C. system. A responsive environment is typically a smart system, and often presents a hybridization between architecture and technology (Bullivant, 2006.). However, in the context of architecture, a smart system refers to an intelligent environment, that might use smart materials, but not necessarily. Understandably, art, design and architecture disciplinary realms have strong tradition of humanism, and in designing considering humans and their bodies as the centre and measure of all things. Therefore the interdisciplinary encounter within U.C., materials, and human factors offers mutual novelty, specifically by building on different traditions and backgrounds.

4. Defining problems within design and computing research

Smart materials resulting from engineering research are effective systems, but their applications in life are less obvious. Often, smart materials are described as a “technology push”, in the case, materials looking for a problem resolution (Addington & Schodek, 2005).

On the other hand, the issue of incorporating social-cultural values in UC research, this being within the material turn, or not, begins with its definition. U.C. is described as a “platform for encounters between people and technology”, proposing, fundamentally, a disciplinary “conversation”: science and technology studies, sociocultural anthropology, and media and cultural studies. These might be particularly relevant when defining problems (Dourish &

Bell, 2011.). However, Dourish and Bell state that there is a dearth of trends in U.C. that focus on an “emancipatory and democratic information technology”, visions “involving people in public debates”, and “issues of science and governance concerning climate change, environmental pollution, health care”. The acknowledgment of research outcomes “in the social sciences” “concerning, learning, participation, motivation, and behaviour change”(Dourish & Bell, 2011) is absent. Indeed, these are problems that U.C. is not typically addressing, and identify terrains for innovative exploration and contribution stemming from the humanities and arts.

The human-to-human interaction design model has social and cultural values prevail over technology. The privileged placing of technology would be to function on the background. As such, defining what problematic terms such as ‘social’ and ‘culture’ might mean in the context of UC research becomes imperative. To frame a practice led research social framing can range from locating settings - the workplace and factory, schools, domestic environments (Dourish & Bell), to analyse impact, as is the case of evaluating sustainability. Indeed culture is a problematic term. As a subject of study, academic definitions are substantially different, varying according to traditions in both sides of the Atlantic. Further dispersion can be found when examining design “cultures” among disciplinary backgrounds (Dourish & Bell, 2011.). In fact, specifically for the concern of a design-led research, culture will be suggest to firstly i) consider it as a generative process, secondly ii) as a method of analysis that enables to give an account of everyday phenomena, and in the context of UC iii) the “examination of information technology as a site of cultural production” (Dourish & Bell, 2011.).

In addition, the symbolic value of materials can be tackled by an ethnographic approach. But specifically, as the purpose of research in U.C. is to design “new devices”, insight can be retrieved from A.D.A., supported by a contribution from the theories of media, as specifically found in Bolter’s concept of remediation (Bolter & Grusin, 2000). This term accounts for historical continuity both on contents and practices in media design. Remediation examines media by displaying hybridization as a continuous dialogue between new and old narratives. In Bolter & Grusin’s description, ”the representation of one medium in another remediation (…) is a defining characteristic of the new digital media.” In other words, cultural inter-relations are acknowledged, and are pursued, as factors of analyzis throughout the process of making, and not only from a disembodied theoretical framework. The main point of these relations are that by putting theory and cultural perspectives in contact with the more common accomplishments of U.C., the research outcome might access less explored realms. Moreover, cultural values enhance awareness that a research contribution will become part of a new cultural production, and also part of a heritage (legacy), which is frequently local.

Knowledge acquired by architecture, art and design might give grounding insight to UC goals, by recombining materiality with tested traditions, but this contact can also project future configurations within the humanities, and the disciplinary culture. The material dialogue between the old and new was demonstrated to be mutually beneficial and within the interdisciplinary realms that U.C. pursuits.

5. Conclusion

Ubiquitous Computing research is an interdisciplinary exploration, with a majority expression routed in computer science. Addressing U.C. challenges under a design led research follow a less travelled route, and includes the Humanities and Art contribution. Hence, it follows Weiser's suggestion to start rooted in humanities and art aiming to design computation in human-to-human perspective. This approach to the field of studies of U.C. makes cultural and social factors emerge. As such, to survey the particular perspective on computing given by arts and humanities becomes vital.

In particular, on the proposal to design invisible technology, it would be culture that would prevail as the visibility. Computation would be on the background and the world would regain the perception of its physicality. As such, answering to this call, the "material turn" discusses within UC the particularities of humanistic knowledge. For instance, it presents the reification of computing as hybridization – of the physical and digital - which fundamentally consolidates a relation with several disciplinary perspectives and culture(s) of materiality (e.g. high tech, low tech). Thus incorporating knowledge acquired by disciplines such as architecture, art or design, which are fundamental to discuss intelligent environments or materials.

Designing the future of computation is also taking a look into the past. Bolter's concept of remediation reveals practice led research or *technê* (making/skills/knowledge) as a continuity and repetition of mediated contents and strategies of visibility.

The future is inspired by nanotechnology, which presents myriad possibilities on materials and design arising from the invisibility. It produces powerful outcomes that arise from bottom-up, instead of the typical top-down approach. Nanotech being itself a *technê* have impacted on traditions of ADA. As such, nanotech is a disruptive step in the "culture" of materiality, inspiring new takes on interactivity and on design methods. On the other hand, turning these new materials into content, that is, making them become meaningful experiences at a human scale, oblige to invest their designed "functions" with culture. This is the opportunity that the present discussion reveals. In other words, the incorporation of socio-cultural considerations in the realm of high tech materials is to serve them with communication (symbolic) values. As Dourish realized, and as defined by Weiser, defining problems having cultural-social considerations would be a fundamental contribution to the scope of UC making/practice. This is the take that has a minority presence in the literature.

In sum, exploring meaning within material turn and UC, will rely in, firstly, an inquiry arising from contact with materials, belonging either to a high or low-tech realm, and secondly, an overall consideration of social-cultural values regarding those very materials.

Designing for future generations starts now, and sustainability and ethical issues can be guiding beacons in the realm of system design. As such the art and humanities are included and demanded in the process of disciplinary collaboration as an emergence in discussion and making.

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SECTION 20

EXPERIENTIAL KNOWLEDGE

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DRS2016
Design + Research + Society
Future-Focused Thinking

2016 Design Research Society
50th Anniversary Conference
27-30 June 2016, Brighton, UK

Introduction: Experiential Knowledge

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Since the last decade, the Design Research Society (DRS) has begun to set up Special Interest Groups (SIGs) in response to the requests of its international membership, as a way of providing the DRS members with forums for their interests that they can engage and work actively together internationally. The Special Interest Groups organise events and discussion in a number of ways to facilitate the exchange and development of best practice in the field.

The first Special Interest Group under the umbrella of the DRS is the Special Interest Group on Experiential Knowledge (EKSIG). EKSIG is concerned with the understanding and role of knowledge in research and professional design practice in order to clarify fundamental principles and practices of using design practice within research both with regard to research regulations and requirements, and research methodology.

EKSIG's interest in knowledge in the creative industries has arisen from the modification of PhD degree regulations to include design practice as a significant part of the research process, first in the UK and later in other European countries and Australasia. The inclusion of design practice in research has led to debates about knowledge in research, i.e. about what we mean by a 'contribution to knowledge' and how new knowledge advances the creative fields. In the UK, Research Excellence Framework 2014 (REF2014)'s overview report, art and design is considered 'the largest sector for the production of research through practice, and as such is a leader in the elaboration of emergent approaches to knowledge' (REF2014, p. 90). This confirms that design research is playing and will play an important role in the production of knowledge through research that has practice as the key component in the process of inquiry.

Focus and Aims

Definitions of knowledge and the contribution to the published corpus have significant implications for doctoral examination and peer review of research generally. A central focus of EKSIG is the clarification of research requirements, such as the contribution to knowledge, in relation to the purposes of research and professional practice to advance respective fields. Fundamental to this is a concern with the integration of explicit and tacit knowledge in order to accommodate the complex knowledge of practice within research, including propositional, procedural and experiential knowledge.

The main aims of EKSIG are: (1) to investigate and advance the understanding of 'knowledge' and 'contribution to knowledge' in design research, particularly in areas where the act of designing forms part of the research process; (2) to develop principles and criteria of design research for employing different kinds of knowledge and means for communicating such knowledge; and (3) to encourage the implementation of the principles and criteria developed within the current research policy to promote quality, standards and best practices in research.

Contribution to Design Research

The notion of practice-based or practice-led research, which signifies the inclusion of creative practice, has become a topic for debate in a number of conference series, such as *Research into Practice* (2000–8), *Doctoral Education in Design* (1998–2011), *The Art of Research* (2007–) and *Research through Design* (2013–) conferences.

To contribute to this debate, with a focus on the development of principles and criteria of design research for employing experiential knowledge and means for the communication of such knowledge, the first EKSIG conference was inaugurated in 2007 and has since been organised biennially. Each EKSIG conference has a specific theme relevant to EKSIG's focus on propositional, procedural and experiential knowledge of professional practice within research, as the following: (1) *EKSIG 2007: New Knowledge in the Creative Disciplines* hosted by University of Hertfordshire, Hatfield, UK; (2) *EKSIG 2009: Experiential Knowledge, Method and Methodology* hosted by London Metropolitan University, London, UK; (3) *EKSIG 2011: SkinDeep – Experiential Knowledge and Multi Sensory Communication* hosted by University for the Creative Arts, Farnham Castle, UK; (4) *EKSIG 2013: Knowing Inside Out – Experiential Knowledge, Expertise and Connoisseurship* hosted by Loughborough University, Loughborough, UK; and (5) *EKSIG 2015: Tangible Means – Experiential Knowledge Through Materials* hosted by Design School Kolding, Kolding, Denmark. The next EKSIG conference will be hosted by Delft University of Technology (TU Delft) in the Netherlands in 2017. The theme of the conference is *Alive, Active, Adaptive: Experiential Knowledge in Designing with (Im)Materials*.

All papers selected for presentation at the EKSIG conferences are published in the conference proceedings. After each conference, the papers are selected for further development for a special issue of an appropriate journal. Since 2007 EKSIG has collaborated with the following journals to publish special issues: (1) *Journal of Visual Arts Practice*'s Special Issue on New Knowledge in the Creative Disciplines (Volume 6, Issue 2, 2007); (2) *Journal of Research Practice*'s Special Issue on Research Practice in Art and Design: Experiential Knowledge and Organised Inquiry (Volume 6, Issue 2, 2010); (3) *Journal of Art* *and Design Education in Higher Education* (Volume 10 Issue 2, 2012); and (4) *Journal of Research Practice* (Volume 6, Issue 2, 2015).

In addition to the EKSIG conference series, the Special Interest Group provides other recognised outlets for research, for example through strands at the DRS conferences or other related events. EKSIG also provides an identifiable focus for researchers with interests in experiential knowledge related to design and a forum for debate through a dedicated jiscmail discussion list as well as promoting collaborative research and its dissemination.

EKSIG Strand at DRS 2016

As knowledge gained by experience, experiential knowledge signifies a way of knowing about and understanding things and events through direct engagement with people and environment. The EKSIG strand at the DRS 2016 aims to examine experiential knowledge, thinking and knowing at the core of design practice, with an attempt to illuminate how a design process conducted in a research context begins and ends in the domain of experience, which is in turn changed by design.

Questions of interest are concerned with, for example:

- Methods for the communication and transfer of experiential knowledge within design research;
- The contribution of design practices to the understanding and communication of experiential knowledge in design research;
- Frameworks for guiding the reception and interpretation of professional design practices and/or artefacts within research;
- Issues evolving from criteria of research such as repeatability and transferability for the foregrounding of tacit knowledge in design research.

In response to the call, the EKSIG strand received 15 submissions from eight countries including Australia, Brazil, Belgium, Mexico, Russia, Turkey, UK and USA. Submissions were interdisciplinary and stem from a variety of disciplines within the design domain, such as architecture, experience design, industrial design, interaction design, participatory design, textile design and service design.

After a double blind review process by the conference's international review panel of 18 reviewers, four contributions have been accepted for presentation at the DRS 2016 conference. Selected papers present research and case studies that contribute to a systematic approach to studying and integrating experiential knowledge and knowing into design practice and research.

The first paper in the EKSIG strand entitled 'Double-Loop Reflective Practice as an Approach to Understanding Knowledge and Experience' by John Gribbin, Mersha Aftab, Robert Young and Sumin Park explores approaches to developing practitioner awareness of their own reflective practice. It expands an area of inquiry concerning tacit and explicit (skills) areas of design knowledge through double-loop reflective practice that potentially provides greater awareness of tacit knowledge and experience. Second, Valerie Van der Lindena, Hua Dong and Ann Heylighen's paper titled 'Designing "little worlds" in Walnut Park: How architects adopted an ethnographic case study on living with dementia' addresses how architects understand the users of their designs, with a focus on how to most fruitfully promote effective knowledge transfer. The paper argues for ethnographic research in architectural practices as a helpful research approach to identifying specific designerly ways of knowing about users. Third, 'Bonding through Designing; How a Participatory Approach to Videography can Catalyse an Emotive and Reflective Dialogue with Young People by Marianne McAra presents a study in which participatory design practice, focusing on the use of direct animation techniques, were used to enable dialogue with vulnerable young people who can be described as being with the NEET (Not in Education, Employment or Training) group. Several key contextual and methodological findings are reported through the author's reflective account. The last contribution to the strand is Valerie Van der Lindena, Iris Van Steenwinkela, Hua Dong and Ann Heylighen's paper 'Designing "Little Worlds" in Walnut Park: How Architects Adopted an Ethnographic Case Study on Living with Dementia'. In this paper, an ethnographic case study about a person living with dementia is examined as an example of knowledge transfer from the research context to the architectural design process of a residential care facility.

Although the four papers differ from one another in scope, the issues relating to tacit knowledge and the value of experience within design processes form a clear link between them.

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Double-loop reflective practice as an approach to understanding knowledge and experience.

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Abstract: The main aim of this paper is to consider the way in which reflective practice can assist practitioners in better understanding their individual knowledge and experience. Transitioning from a design novice to a design expert is described as a vague process, in which reflective practice can offer a level of understanding that provides an important insight into professional development within design. Through a comparison of two methods of reflection and analysis of reflective practice data, it is argued that repertory grid interviews have the potential to be a catalyst for double-loop learning within individuals; providing people with a platform to reflect on their beliefs and values in addition to their approach towards problem solving. This argument is based on the ability of repertory grids to uncover some of the implicit knowledge developed by designers, which is a distinct advantage to alternative methods of reflection and which is necessary to improve professional practice understanding and learning.

Keywords: Reflection, Design knowledge, Design experience, Repertory grids.

1. Introduction

Within design practice, reflection is critically important in translating experience into the development of new skills, attitudes, knowledge and capabilities. This is epitomised by Schön (1991), who argues that experience alone does not necessarily lead to learning and that a deliberate reflection on action is necessary in order to fully understand one's experiences. The resulting experience, knowledge and intuition become critical in a designer's attempt to solve complex problems and navigate a design space when creating innovative solutions. Experienced designers have the capability to apply their knowledge to any given context and this paper will consider the way in which reflective practice can support this, by allowing practitioners to become more aware of their knowledge and experiences.

Within the leadership function of organisations, Aftab (2013) identifies that designers can typically be categorised into thinkers and practitioners. Design thinkers are those who work with strategies and solutions to problems facing organisations in the distant future (over twenty years) and consequently have an involvement in the formulation of the future of the company. Contrastingly, practitioners are those who work to create scenarios that are applicable in the present, in terms of relevant products and services. In doing this, they follow the direction provided by the thinker in order to achieve the goals identified for the future. Both of these roles require a variety of tacit, implicit and explicit knowledge, however this paper argues that propositional and non-propositional knowledge stand out as a key differentiator between the two roles.

The authors of the current paper take the viewpoint of outside researchers looking into organisational innovation practices, as opposed to that of a reflective practitioner reflecting upon their own actions. It also follows the belief that not all knowledge can be explicated, however it is the role of researchers to uncover and document as much of this knowledge as possible. This is a viewpoint underpinned by Polanyi (1958), who argues that not all types of knowledge can be understood; instead some types of knowledge such as the arts have limited capability for transfer; they cannot be transferred by prescription, since no prescription for it exists. Subsequently the only way for this type of knowledge to be transferred is from person to person, such as from an expert to a novice. As a result, it is only possible to explicate a finite amount of knowledge in any given situation.

The intention of the paper is to consider methods that will translate as much of the implicit skills and knowledge of the design practice process as possible, which merges into tacit elements. The paper will begin with a discussion of knowledge in relation to design professionals, before considering the relationship that knowledge has with experience.

2. Knowledge within design

2.1 Thinkers and practitioners

The articulation of design knowledge entails defining what designers 'knowingly-think' (explicit knowledge), 'knowingly do' (implicit skills) and 'unknowingly do' (tacit knowledge). In reality, most knowledge in design practice has been claimed to be either tacit or implicit (Cross, 1984), or a combination of both (Smith, 2001). Furthermore, Young (2008) confirmed that certain forms of implicit knowledge can be made explicit such as 'craftsmanship and its strategy' in the form of a design outcome, but this is not likely the case for other forms of tacit knowledge, which are both hard to understand as well as difficult to articulate explicitly.

Polanyi (1958) and Wilson (1999) provide two different and rather contradictory views on knowledge. Whilst Polanyi believes that certain types of knowledge will always remain tacit and inbuilt in human intellect, Wilson provides the concept of consilience, which maintains that in future all branches of knowledge will be known, made orderly and organised.

Arguably, design knowledge poses a challenge to Wilson's notion of consilience, as knowledge in design has been a contentious matter, which is made worse because of the conflict between design theory and its practice. The evidence collected during an investigation with multinational organisations (Aftab 2013) also confirmed this conflict; where the thinkers and the practitioners within the innovation team were divided in their knowledge, way of working and priorities. Thinkers in the organisation proved to have a strong foundation of propositional knowledge (Gemma 2014), based on an awareness of 'how' an innovation process should work to overcome future challenges. Contrastingly, the practitioners held the working knowledge of 'what' needs to be done to make innovation happen on a day-to-day basis; more closely aligning practitioners with a foundation of procedural knowledge (Niedderer 2007).

Both thinkers and practitioners hold two very important types of knowledge, i.e. explicit knowledge and implicit skills. Nevertheless, there was one peculiar knowledge type that existed in both the groups, and was very difficult to articulate i.e. tacit knowledge. Casakin (2007), Cross (2008), Pugh (1990) have all identified where tacit knowledge resides within design activities, but the ways in which this knowledge could or can be made explicit and recognised by the practitioner is still inchoate.

2.2 Articulating knowledge and experience in design innovation practice

Aftab (2013) confirms that the explicit definition of certain aspects of design knowledge, such as process, methods, and tools for design, is essential in order for design to gain and maintain a functional leadership role within an organisation. This involves making sure that every individual working within the innovation process (whether a thinker or a practitioner) is aware of what they are doing, to improve their design performance in problem solving; a process that Schön (1987) named as *knowing-in-action.* Schön described, *Reflection-in-action* as having a critical function, questioning the assumption structure of *knowing-in-action*, more commonly also known as critique (Evans, Powell, and Talbot, 1982). Schön (1987, pp.39) explained that individuals reflect on their way of thinking which places them into a particular situation; and through this process of reflection these individuals may reorganise strategies of their action, understanding the experience, or techniques of problem framing.

It is important to note here that knowledge appears to develop through experience within design practice, where experiential knowledge becomes an important factor underpinning the decisions made by practitioners. Novices tend to solve problems by attempting to represent and classify the problems by their surface features, whereas experts represent them in terms of their underlying features (Chi, Feltovich et al. 1981). Robinson (2010) highlights that experts are at a great advantage in solving complex problems, in that they have a richer store of relevant knowledge and an ability to conceptualise it in ways that enable them to perceive possible problem solutions. Voss (1989) further emphasises this view, indicating that good problem solving emerges from a person having a substantial knowledge base integrated with knowing how to apply that knowledge to a wide range of problem contexts. This suggests that as designers gain more experience, their overall competence in terms of solving complex problems also increases. Their exposure to a variety of problem situations provides a solid basis from which they are able to draw experience and tailor their abilities towards the new problems that they face. The next section will further consider the role of experience within the development of design professionals.

3. Experience within design

Lawson and Dorst (2009, p.216) argue that expertise within design is not acquired in a continuous seamless manner, instead it is suggested that there appear to be more or less distinct layers of expertise that allow different modes of thinking and action. It is widely believed that experts differ from novices in that experts are aware of a greater number of concepts, organise information on the basis of identifying principles and are capable of applying concepts in a flexible fashion contingent on the key characteristics of a situation (Mumford, Marks et al. 2000). Transitioning from novice to expert is of core importance when considering the journey of a design professional, however there is much debate surrounding the distinction of individual experience levels that occur on this journey. Heskett (2002) writes about this process as layering, where new developments through experience are added over time to what already exists. In this context, layering is a useful term to describe the process by which design knowledge is formed by integrating 'designerly' approaches to identify the richness of design activity. The journey from novice to expert is documented in the rest of this section and is summarised in Appendix 2.

Perhaps the most extensively utilised model of skill acquisition is provided by Dreyfus and Dreyfus (1986, 2002), who suggest that there are five stages in the human skill acquisition process with an individual transitioning from novice to expert with increasing exposure to skilful practice. The first stage of novice occurs when a person is provided with rules for determining actions within a given situation, which they will follow rigidly until they reach the desired outcome. The learner then transitions to advanced beginner when they have gained experience working within real situations and learned that the rules don't necessarily apply to all situations. Furthermore, this is the stage in which experience becomes more important than any form of verbal description. Upon gaining a certain amount of experience, people then enter the competency phase, in which the number of recognisable context-free and situational elements present in a real-world circumstance eventually become overwhelming. People learn a hierarchal procedure of decision making in order to solve these problems, by choosing a plan to organise a situation and examining the most important factors to that plan.

When people enter the two highest levels of skill, their approach to problem solving is characterised by a rapid, fluid, involved kind of behaviour that contrasts to the problem solving approaches used within the lower levels. Proficient learners are capable of considering the rules to a situation, before making conscious choices of both goals and decisions after reflecting upon a range of alternatives. Proficiency is only developed if experience is assimilated in a way in which intuitive behaviour replaces reasoned responses (Dreyfus 2002). The expert performer differs from the proficient performer in that the expert is capable of seeing what needs to be achieved and sees how to achieve their goal. With enough experience, the expert is capable of providing an immediate intuitive situational response to a problem, due to their experience in a variety of different situations.

Within design practice, Lawson and Dorst (2009) criticise the use of the Dreyfus framework in that design is not just limited to people who are formally trained in the subject. This leaves questions surrounding a framework that begins at the novice level, given that people are capable of designing without even realising that they are doing so. Despite this, Lawson and Dorst (*ibid*.) argue that the Dreyfus framework provides a strong foundation to encourage thinking about the development of expertise in design. Dorst (in: Poggenpohl and Satō 2009) takes measures to build on the Dreyfus framework in a way that addresses his earlier critique; suggesting that a 'naïve' level should be added in order to precede the novice stage of skill. The 'naïve' state of designing is adequate for explaining the design-like tasks that non-designers carry out in their day to day life, in which people have unsystematically gathered experience. Furthermore, Dorst (*ibid*.) proposes an additional level of experience, superseding mastery, in the form of a 'visionary', in which a person becomes so interested in developing new ideas that the normal level of expected professional competence becomes less important. The work of such designers may often not be realised but it is deemed necessary as visionaries are explicitly redefining the design field that they are working in. This is echoed by Sennett (2008), who refers to craftsmen in society who are capable of utilising their mastery in order to change the methods and tools of their craft in order to contend with the evolving nature of the problems and contexts that they are working within.

Ultimately, this leads to a refined framework of experience that could be mapped against a range of design career paths, however there are still questions that need to be answered in order for these types of frameworks to comprehensively explain the way in which individual designers develop mastery of their subject. The existing framework is particularly oriented around the skills of a designer, when arguably other factors must also be considered to provide a comprehensive explanation of a designer's expertise. Aspects such as knowledge and attitude also play an important role in design problem solving and should be reflected in future frameworks. Furthermore, it can also be difficult to recognise when people are transitioning from one level to the next. Dorst (in: Poggenpohl and Satō 2009) argues that in order for people to progress they must first acquire sufficient knowledge within a particular level. Next they must undergo a mental realisation that their newly acquired knowledge and skills can be utilised in a new and different way. This paper argues that reflection is capable of being a catalyst for this process, as the leap from one level of experience to the next can be a difficult transition for individual learners.

4. Reflection and double-loop learning

Schön (1991) argues that within the context of design, experience alone does not necessarily lead to learning and that a deliberate reflection on action is necessary. In order for people to translate their tacit understanding and implicit skills and experiences into learning and explicit knowledge, they must engage with the process of reflection in order to articulate this value. Being able to reflect upon experience in this way can help individual learners to align their individual competencies within a given framework of expertise and form a better understanding of their development as a design professional.

Schön and Argyris (1974) highlight two different learning strategies that involve experience-based learning and can be driven by the process of reflection and is visualised within figure 1. The first strategy is single-loop learning that involves the creation and adoption of new action strategies in order to understand inner values. This often takes the form of problem solving with individuals attempting to improve the systems they operate within. Contrastingly, double-loop learning occurs when people focus on the improvement of their inner values as opposed to merely understanding them. People begin to question the underlying assumptions behind their techniques, goals and values in order to understand why they do what they do, as emphasised by Cartwright (2002, p.68) who indicates that 'double-loop learning is an educational concept and process that involves teaching people to think more deeply about their own assumptions and beliefs'. Within the context of these two strategies, the purpose of reflective practice is to allow individuals to describe a world that more faithfully reflects the values and beliefs of the people in it (Greenwood 1998).

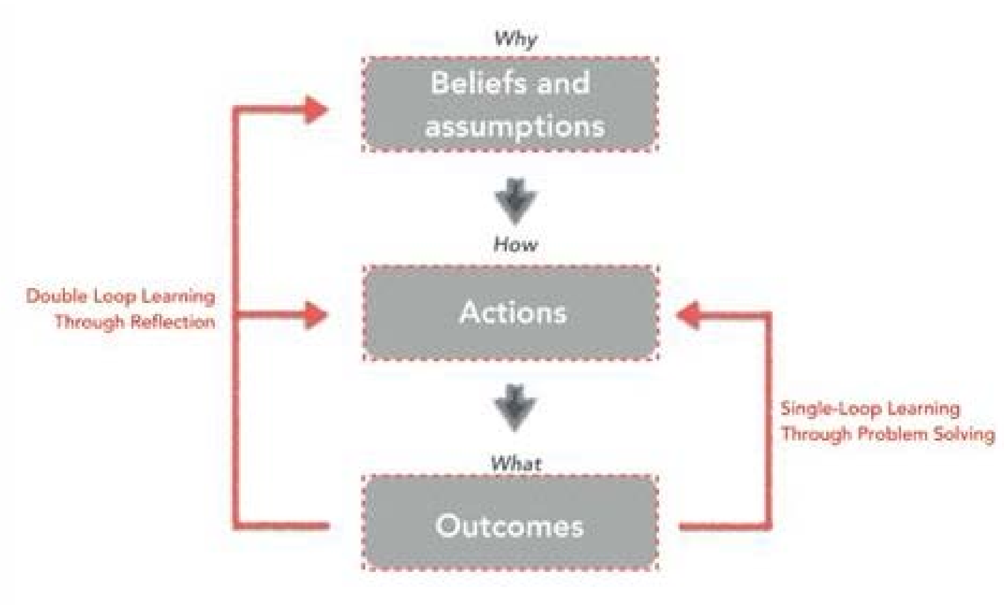

Figure 1: Single and double-loop learning.

According to Argyris (1976), double-loop learning is focused upon improving the problem solving capabilities of people who are involved in solving complex and ill-structured problems, which are capable of evolving as problem solving advances. This makes double-loop learning especially desirable within the context of design-led organisations, where both thinkers and practitioners are typically expected to solve problems that operate within these boundaries (Rittel and Webber 1973, Stacey, et al. 2000, Coyne 2005, Dorst 2011). Furthermore, this style of learning is pertinent within cultures that embrace failure and view it as an important tool for learning (Liepė and Sakalas 2015). This is an approach typically favoured by organisations seeking to engage with radical innovation by following design-led innovation practices (Verganti 2009). In this situation, organisations that learn how to fail intelligently consistently outperform those that seek to minimise the frequency of failure (Schrage 1989, Sudheim 2013).

Double-loop learning can therefore be used to help both organisations and practitioners better understand the underlying beliefs and assumptions that govern their actions. In the case of organisations, this can benefit innovation practices, by improving performance when solving wicked problems that present themselves. With regards to individual practitioners, double-loop learning can provide individuals with a more holistic learning experience, ensuring that individuals are better aware of their professional experiences, which is of great importance within practice-led professional learning. With these benefits in mind, the next section will discuss the methodology that the paper adopts in considering which methods are most appropriate in facilitating double-loop learning.

5. Methodology

This paper follows the approach of grounded theory, combined with case study analysis in order to investigate methods that are capable of facilitating reflection. Grounded theory was initially proposed by Glaser and Strauss (1967) as a ‘systematic generating of theory from data that itself is systematically obtained from social research’ (Glaser, 1978 in: Hussein, et al. 2014). It is an inductive method of generating theory through the simultaneous collection and analysis of data, with the goal of generating relevant and significant knowledge through social research. Grounded theory has limitations in that researchers can often blur methodological lines by selecting purposeful instead of theoretical sampling (Charmaz 1990), which must be controlled by sampling based on emerging theory. Within this paper, the goal of grounded theory was to derive fresh insights into existing case studies and as such, the sampling was guided by the selection of relevant cases.

Yin (2014) identifies case studies of empirical enquiry that investigate a contemporary phenomenon in depth and within its real-world context; particularly when the boundaries between phenomenon and context may not be clearly evident. Similar to grounded theory, cases provide an opportunity to explore propositions and generate theory from the resulting data. Grounded theory is often limited in terms of its generalisability with theories often only relevant to the context in which they are derived (Stebbins 2001). Combining it with case study research appears to mitigate the effects of this issue, as the use of multiple cases begins to provide examples derived from multiple experiments that investigate phenomena under different conditions (Lipset, et al. 1956, Hammersley, Foster et al. 2000, Johansson 2003).

Eisenhardt (1989) highlights that case studies typically combine multiple methods, which may be qualitative or quantitative in nature. Within this study the primary data collected was qualitative and collected through workshops that occurred within the setting of design education. The workshops aimed to encourage reflection in twelve multidisciplinary postgraduate students, with the aim of explicating some of the knowledge and skills that were developed over the course of three different design focused projects. The projects in question were all client driven, with the first focusing on stakeholder engagement for a non-profit organisation. The second project aimed to analyse the structure of an organisation through an evaluation of membership platforms available to their clients; whilst the final project was brand driven, offering a fresh perspective on potential avenues of future business development as well as alternative methods of improving customer experience.

6. Analysis of methods

6.1 Introduction

The previous sections of this paper have discussed the importance of reflective practice to both organisational learning and individual design professionals. This section will build on this discussion by outlining the methods that are available to individual design practitioners in order to facilitate reflective practice with the goal of creating double-loop learning. Primarily, an objective researcher has facilitated these methods and assisted in the interpretation of findings in order to maximise the value gained by the reflective practitioner.

6.2 An overview of reflective methods

Reflective practice is common across a wide range of disciplines, with a variety of methods being utilised to facilitate the process. In order to analyse some of these methods in more detail, Appendix 1 provides an in depth overview; outlining a definition of each method alongside any advantages and disadvantages noted by other studies, as well as highlighting any studies that utilise the method to facilitate reflection.

Due to the scope of the paper, it is impossible to further discuss each method of reflection individually; therefore the remainder of the paper will discuss methods that appear to be most relevant in facilitating double-loop learning within design practitioners. Whilst all of the mentioned methods are effective when it comes to facilitating reflection, not all of the methods are capable of eliciting implicit knowledge and skill leading to the tacit dimension, which reduces their appropriateness for this work.

6.3 The repertory grid technique

Although workshops facilitated with interviews and observations proved to be a useful tool in understanding the explicit knowledge that is held by practitioners, they only offered a small insight into the implicit elements that contribute to professional practice. As a result, it is important to consider methods of reflection that are capable of beginning to uncover some of this knowledge. Appendix 1 shows that repertory grid interviews fit these criteria. Subsequently this section will consider the merits of the approach as a reflective method.

A repertory grid is a method for eliciting personal constructs in relation to a given topic. The method was derived by Kelly (1955), who expressed that people are continually engaged in the process of devising new theories, testing hypotheses based on these theories and acting on their findings (Giles 2002). Kelly (1955) described this process as personal construct theory, arguing that individuals construct rational worlds based on their experiences, which shape a pattern that can be defined as 'personal constructs'. Candy (1990) describes a system of personal constructs as a repository of what a person has learned, a statement of their intent and the values by which they live. As a person builds up their construction of reality, more and more constructs are derived until eventually a complex and unique picture of one's reality is formed; thus demonstrating the way in which a person organises their social world, which is then open to interpretation.

Repertory grids are often utilised in order to facilitate the articulation of various personal constructs. A repertory grid takes the form of a table or matrix that can contain either quantitative or qualitative data. Tables consist of columns of elements, which define the area of study and rows of constructs, which are themes that link various elements together (Giles 2002). Constructs within the grid are always bipolar, meaning that they comprise two opposing values, which helps to ensure that they can be distinguished from other concepts. This process is perhaps best described by Persson (2009, p.254), who expresses it within the context of an interview situation:

"If Anne is interviewed and the topic is [her] friends she might say that Mary and John are nice and Sally is not. This is the elicitation of one pole of a construct but it would not be complete without the other pole. Anne will now describe the attribute that Sally has that is contrasting to nice. If she says that Sally is unpleasant compared to the other two, the two poles of the construct [are] nice and unpleasant. Anne will then rank all the elements, her friends, according to a scale. The procedure continues until it is no longer possible for Anne to elicit more constructs."

When conducting a repertory grid interview, the facilitator can ask questions in a way that target both emergent and implicit constructs (Fransella, Bell et al. 2004). Emergent polls can be derived by asking a person to explain the way in which two elements of a triad are in some important way similar and thus different from the third element. In order to uncover implicit constructs, the facilitator can then ask how the third element is different from the two that were stated to be similar. Björklund (2008) suggests that eliciting constructs in this way allows researchers to understand the implicit learning that occurs through the progression of a professional craftsman from novice to expert. The repertory grid technique can elicit implicit constructs and patterns that would not be possible to elicit through regular ordinary interview techniques as the information is not stored in verbal form. Therefore, asking participants to consider implicit constructs in this way begins to uncover some of the tacit knowledge that they possess.

One of the biggest advantages of the repertory grid technique is that it can be used in facilitating double-loop learning for individual practitioners. The aim of personal construct theory is to document a person's reality with regards to individual situations, which can be directly utilised when understanding the beliefs and assumptions that underpin their decisions within a particular context (Kelly 1955). Furthermore, the technique can provide an insight into the tacit knowledge held by practitioners (Jankowicz 2004), which is hugely beneficial in the design profession where both thinkers and practitioners need to become more aware of the tacit factors that contribute to their overall expertise.

As a research method, repertory grids are particularly useful in understanding the views of others without misinterpretation from an outside source (e.g. a researcher). It is easy to talk to a person and believe that we have understood them, however unless their personal constructs are well understood there is a risk that our own thinking will simply be transferred to the situation (Jankowicz 2004). By highlighting as many personal constructs as possible and ensuring that the person reflecting spends time developing bipolar constructs, there is minimal interruption from the facilitator leading to a specific insight into a situation, thus reducing the potential for bias as a research method.

Authors such as Tofan *et al*, (2011) and Anderson (1990) find that when using the repertory grid technique within different situations, one of the main disadvantages is the time that it takes to implement the method particularly in relation to alternative psychometric tests. Equally, Tofan (*ibid*.) highlights that participants can find it difficult to interpret the data that they create when reflecting through this method. Subsequently, the implementation of the method as a tool for reflective practice would have to be carefully facilitated in order to guide participants in both creating and interpreting their own grids. Despite this drawback, the repertory grid technique appears to be one of the most useful techniques for encouraging reflection and double-loop learning within design thinkers and practitioners. They are a viable tool in uncovering the personal constructs of individuals, which provides an insight into the tacit and explicit knowledge and experience that they have acquired in their practice. As a result it is possible that the repertory grid can be utilised in order to help thinkers and practitioners better understand their experience in relation to a given framework of expertise.

6.4 A reflection on the repertory grid process

One of the primary aims of the pilot study was to explore whether it was possible to implement the repertory grid technique in a workshop setting, rather than through individual interviews. The success of the method under these circumstances would have allowed a researcher to provide a greater ownership of the method to the participants, resulting in a method capable of facilitating double-loop learning without an independent researcher having to guide the process. From this, it would have been possible to utilise the method in a greater range of circumstances, as it would be less resource intensive to implement it. However, the data provided by the students in the workshop setting was consistent with the approach of single-loop learning, with a large focus on the methods that were used throughout the projects and little comparison of the deeper beliefs and assumptions that underpinned decisions. Within a one on one interview process, it is possible for a researcher to overcome this issue by using a process of laddering, in which constructs of a higher order of abstraction can be elicited (Fransella, Bell et al. 2004). Laddering involves the elicitation of constructs through triadic comparisons, before asking a person to say by which pole of each construct they would prefer to be described. From this they are asked to consider why they prefer that particular construct and the advantages to that construct as they see them (Hinkle 1965). This process allows the students to consider the system through which they are working in much greater focus.

The results of the workshop also provided an interesting insight into the attitudes of the students taking part in the projects. Through conducting a correlation analysis on the numerical ratings that students gave to each individual construct, it was possible to determine which aspects of the projects were statistically related. This highlighted the aspects of each project that students found engaging and which they found frustrating. This is of importance to researchers investigating a growing body of research surrounding design attitude (Boland and Collopy 2004, Michlewski 2006, Nelson and Stolterman 2012). This type of study frequently investigates the factors that designers and people from a broader range of disciplines find engaging and frustrating when collaborating across innovation projects; which is essential when trying to derive a picture of the culture of an organisation.

Furthermore, the students themselves responded positively to the method when asked how they felt about the process. They particularly felt that the comparison between projects made through repertory grid gave it a distinct advantage over the other methods of reflection that they had previously utilised. Through the comparison of different projects, they were made to think differently about the skills and knowledge that they had developed over multiple projects and were given the opportunity to consider how these aspects of their competency had been developed over time. Perhaps most importantly, the students appeared engaged throughout the entire process, as it is critical that a method of reflection has this effect as if the opposite is true it is unlikely that people will fully engage and that any double-loop learning will occur.

7. Conclusion

7.1 Summary

The main aim of this paper was to consider the way in which reflective practice could assist practitioners in better understanding their experiences, in order to improve their overall practice. Design knowledge is often referred to as being episodic, in that it is derived through our experiences (Lawson and Dorst 2009). Authors such as Chi *et al*. (1981), Robinson (2010) and Voss (1989) all highlight that knowledge develops with experience of design practice; resulting in experts being able to problem solve more effectively than others who may be less experienced. Despite this, Dorst (in: Poggenpohl and Satō 2009) indicates that we are still unaware of the way in which a professional might increase their considered level of expertise. Transitioning from novice to expert can be a vague process, however there are clear distinctions as to the steps that occur along the way. It is argued that reflective practice can help practitioners to understand their own experience and knowledge, in turn assisting them as their expertise develops over their careers.

The paper adopted a methodology of grounded theory and case study analysis to consider a range of reflective methods that could give practitioners a better insight into their experience. Through workshops, it was determined that design professionals appear to develop the specialist knowledge associated with the role of thinkers or practitioners when they begin their career within an organisation (Aftab, 2013). Furthermore, in certain situations, effective reflective methods need to allow a person to reflect on the influence of others as well as themselves in the decision making process. From the methods analysis, it appears that the repertory grid technique has the potential to be a suitable method for enabling double-loop learning within design professionals, with its ability to uncover tacit knowledge being a particularly strong advantage over the alternative reviewed methods.

Repertory grid has the potential to be utilised as an independent form of enquiry, however for best results it should perhaps be combined with a form of reflective or reflexive conversation. The current study utilised workshops as a way of facilitating these conversations, engaging with multiple practitioners at the same time in order to efficiently collect data. Repertory grid also needs to be facilitated by an objective researcher in order to guide the process and encourage the participant to reflect on appropriate incidents. Further research should look to implement this approach and document the findings in relation to mapping out the experience of design practitioners.

7.2 Implications for future work

An argument has been constructed, through a limited empirical study, in favour of the use of repertory grids as an effective method to create double-loop learning in design practice. It appears to be the most effective method of reflection that is capable of uncovering tacit knowledge within practitioners whilst allowing people to reflect deeply on their beliefs and assumptions as well as their actions in a given situation. To further this work, studies should seek to implement the repertory grid approach across design professionals from a range of experience levels in order to ascertain relationships; between levels of experience and breadths and depths of explicit, implicit and tacit knowledge and whether and how these might reinforce double-loop learning to support the growth of professional knowledge. Such studies would further validate the method’s appropriateness in helping individual designers to better understand their design practice and as a result help to improve their overall performance. Also, they would help reduce the vagueness of the process of designers transitioning from a novice to an expert practitioner and how this relates to descriptions of competence in organisations.

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Appendix 1

Reflective processes & methods	Description	Studies	Advantages	Disadvantages
Critical incident analysis	A set of procedures for collecting observations of human behaviour in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles' (Flanagan, 1954, p.1).	Butterfield *et al*, 2005; Tripp, 2011; Cope and Watts, 2000; Hughes et al, 2007	Data is collected directly from the participants in their own words. Flexible method for participants to engage with. Highlights key points for personal change/development.	Critical events may not be recognised at the time. People might not recognise the importance of an event within a wider social context. Biased towards events that are considered recent.
Reflective journals	Reflective practice journals give space for regular, frequent, private, explorative and expressive writing (Bolton, 2014).	Uline, 2004; Francis, 1995; Pyhtila, 2014; Al-karasneh, 2014; Phani, 2012; Paton, 2012	Can make different connections between different situations. The writer can share aspects of the journal at their own discretion.	Not everyone prefers to communicate through writing or drawing. May be largely descriptive with little analysis. Difficult to uncover tacit knowledge.
Repertory grids	An interview technique utilised in order to elicit personal constructs and individual beliefs.	Kearns *et al*, 2003; Anderson, 1990; Hassenzahl, 2000; Korthagen, 1993; Solas, 1992; Hill *et al*, 2015; Young, 1989	Can be difficult to implement. Elicitation of personal constructs needs to be handled in a sensitive manner. Can be used to explicate tacit knowledge.	The interviewer can access the participants views of their own worlds. Can offer insights into a rich source of data. Construct elicitation comes entirely from the participant, minimal researcher intervention.
Reflective and reflexive conversations	Conversations in which the facilitator asks a series of questions designed to encourage reflection in participants.	Goodfellow, 2000; Moore *et al*, 2001; Gray, 2007; Black et al, 2000	Can help the process of reflection in action and the search for new perspectives of a situation.	Need to critique assumptions that are made through the process (Palmer and Dumford, 1996).

Appendix 2

The following table collates definitions of the seven levels of experience within design, with definitions taken from: Dreyfus and Dreyfus (1986), Dorst (in: Poggenpohl and Satō 2009) and Lawson and Dorst (2009).

Stage of Expertise	Description
NAIVE	The Naive state of experience is adequate for explaining the design-like tasks that non-designers carry out in their day to day lives, in which they have unsystematically gained experience in the discipline. This is primarily derived through people engaging with problem solving in a designerly, yet uninformed way.
NOVICE	A novice will consider the objective features of a situation, as they are given by the experts, and will follow strict rules to deal with the problem.
ADVANCED BEGINNER	For an advanced beginner the situational aspects are important, there is some sensitivity to exceptions to the 'hard' rules of the novice. Maxims are used for guidance through the problem situation.
COMPETENT	A competent problem solver works in a radically different way. Elements in a situation are selected for special attention because of their relevance. A plan is developed to achieve the goals. This selection and choice can only be made on the basis of a much higher involvement in the problem situation than displayed by a novice or an advanced beginner. Problem solving at this level involves the seeking of opportunities. The process takes on a trial-and-error character, with some learning and reflection. A problem solver that goes on to be proficient immediately sees the most important issues and appropriate plan, and then reasons out what to do.
EXPERT	The expert responds to a specific situation intuitively, and performs the appropriate action straightaway. There is no problem solving and reasoning that can be distinguished at this level of working. This is a very comfortable level to be functioning on, and a lot of professionals do not progress beyond this point.
MASTER	The master sees the standard ways of working that experienced professionals use not as natural but as contingent. A master displays a deeper involvement into the professional field as a whole, dwelling on successes and failures. This attitude requires an acute sense of context, and openness to subtle cues.
VISIONARY	The visionary consciously strives to extend the domain of operation developing new ways of doing things, outcomes, definitions of the issues, opens new worlds and creates new domains. The visionary operates more on the margins of a domain, paying attention to other domains as well, and to anomalies and marginal practices that hold promises of a new vision of the domain.

Designing "little worlds" in Walnut Park: How architects adopted an ethnographic case study on living with dementia

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Abstract: Understanding future users is recognised to be essential in design, yet also challenging. Often architects have no direct access to the experiences of others, like people with dementia. Case studies have been suggested as an adequate format to inform designers. This paper investigates the role of an ethnographic case study about a person living with dementia, as provided to an architectural firm designing a residential care facility. Interviews with the architects and an analysis of design materials reveal how they incorporated the case study in their ongoing design. Results indicate that the case study offered insight into users' daily life and facilitated architects' concept development. Architects' resulting concept proved valuable to frame design decisions, while its visualisation played a significant role in internal and external communication. The study contributes to untangling important aspects in informing architects about future users and raises questions regarding researchers' and designers' roles in transferring knowledge.

Keywords: architectural design; dementia; ethnographic case study; knowledge

1. Introduction

Understanding future users is recognised to be essential in design (Dorst 2006). Yet, it can be difficult to design for others with considerably different spatial experiences, due to differences in age, gender, ability, ethnicity, profession, situation, etc. (Imrie 2003). This paper concerns people with dementia, who can experience severe disorientation in space, time and identity due to memory loss (Jonker, Slaets and Verhey 2009). The built environment has the potential to support orientation and add to people's wellbeing (Calkins, Sanford and Proffitt 2001; Day, Carreon and Stump 2000; Sternberg 2009). Nevertheless, designing a residential care facility for people with dementia can be challenging, as architects often have no direct access to people with dementia's daily life, experiences, aspirations and needs. Involving people with dementia is often unfeasible for architects, given the amount of time and effort required and architects' unfamiliarity with user involvement (Sanders 2009).

Architects typically need to turn to sources other than their own experience (or direct user involvement) to inform their design for people with dementia, but this is where they encounter difficulties (Van Steenwinkel, Van Audenhove and Heylighen 2012). Traditional research outcomes are difficult to apply, due to, e.g., the lack of spatial aspects in the content and the designer-unfriendly format (Van Steenwinkel 2015).

Information formats should take into account architects' "designerly ways of knowing" (Cross 2006). As outlined below, case studies have been suggested an adequate format to inform decision making (based on, e.g., Flyvbjerg 2001). Taking a closer look at the factors that might have contributed to adopting such a case study can improve our understanding of how to inform architects about experiences of future users that are difficult to access.

This paper analyses the adoption of an ethnographic case study about Mary, a woman with early-onset dementia living at home with her husband (Van Steenwinkel, Van Audenhove and Heylighen 2014). The case study was conducted by the second author, prior to and apart from this study, to offer architects insight into the life of a person with dementia. This paper investigates how an architecture firm adopted the results of this ethnographic case study in their ongoing design of a residential care facility. To this end, interviews with the architects and an analysis of their design materials were conducted.

The results reported below are organised in three sections reflecting the contributions of the ethnographic case study: how it helped to contextualise the issue of dementia, how its main concept was incorporated in the design, and how this concept was expressed. The discussion section untangles important aspects in informing architects about future users whose experiences are difficult to access. This yields insight into the possibilities to inform architectural design through a more prominent position of user perspectives. It also raises questions about the potential roles of both researchers and designers in transferring knowledge from research into design practice.

2. Background

Although numerous scientific studies have been conducted about design for people with dementia, their uptake in design practice is limited. This may relate to the fact that most studies focus on *what* (spatial) aspects are in play in the context of dementia, but leave designers in the dark about *how* and *why* people with dementia use space (Chalfont and Rodiek 2005, p.342). Traditional research outcomes do not fit design practice, neither content- nor format-wise (Diaz Moore and Geboy 2010; Kirkeby 2009; McGinley and Dong 2011; Rashid 2013). A typical list of prescriptive, decontextualized facts with little direct relevance to designing space is hard to work with. Architects designing for people with dementia would rather benefit from information with particular characteristics, namely:

> “being open-ended and descriptive, including information about living with dementia, including information about the physical environment and preferably addressing architects’ core business (form and spatial organization), and being time-efficient.” (Van Steenwinkel 2015, p.30)

To inform architects adequately about future users, like people with dementia, these requirements should be taken into account. As the requirements relate to architects’ “designerly ways of knowing” (Cross 2006), the specific character of the activity of designing (in general) is worth a closer look (Lawson 2010). Design is not a linear process where facts serve as input and a (building) design is produced as output. Given that design deals with ill-structured, wicked problems (Rittel 1971), gaining an understanding of the problem parallel to testing solutions is an essential design activity (Dorst and Cross 2001). This understanding entails a kind of knowledge different from the facts produced by the dominant clinical studies (Diaz Moore and Geboy 2010). For example in the case of architectural design:

> “Understanding is seen as important for the architect, because the production of architecture demands an ability to imagine how others may use and experience a building. To imagine how it is to be in a certain space involves empathy and a personal understanding from the architect.” (Kirkeby 2009, p.308)

Understanding a design problem is essentially (inter)subjective and value-bound, as in every iteration architects have to rely on their own judgement (Darke 1979; Lawson 1994), to evaluate a potential solution in relation to the problem at hand. This reflection-in-action can be observed in different professions, from designers over managers to clinicians, who all seem to know more than they can put into words when assessing ad-hoc complex problems (Schön 1983). Aristotle’s concept of “phronesis” explains the kind of knowledge in play when making such judgements (Flyvbjerg 2001). “Phronesis” can build on scientific facts and personal experience, but it has an extra dimension of morality. That is, architects need to make ‘good’ design decisions, based on preconceived values for future users and in line with the project aim and architects’ self-imposed ambitions.

Case studies have been suggested as an adequate format to inform such ‘good’ decision making (Flyvbjerg 2001, in the context of policy, planning, management). Case studies are particularly valuable because they are episodic sources, i.e., “*particular*, experienced-linked sources which are at the *same abstraction level* as the target problem” (Visser 1995, p.173, emphasis in original). If well-documented, a case study allows understanding the particularities of its context and transferring knowledge from one situation to another. This makes it more useful for ‘good’ decision making than general, context-independent knowledge (Flyvbjerg 2001).

This suggestion to inform ‘good’ decision making equally applies to architects’ design process and was already observed in their use of architectural references, i.e., in transferring elements of other projects to the design problem at hand (Goldschmidt 1998; Heylighen and Neuckermans 2002). Yet, the use of references must be well-considered, and “to be valuable, a reference must carry meaning and a designer must therefore have sufficient intimacy with it” (Goldschmidt 1998, p.266). In this paper, we investigate the potential of an ethnographic case study, providing insight into the spatial experience of a person with dementia, as a format to inform architects' design process.

3. Methods

The empirical data were collected as part of a larger qualitative ethnographic study, which aims to gain insight into architects' "designerly ways of knowing" about users. The first author conducted six weeks of ethnographic fieldwork in the architecture firm named studio:ratio,[221] where she followed various design projects.

Studio:ratio is an acclaimed Brussels-based architecture firm consisting of nine architects (including two partners and two interns). The firm mainly works on public projects (granted through competitions) like schools and collective housing. One of the partners gained experience in designing residential care facilities in his previous firm.

This paper focuses on an ongoing design project called Walnut Park, a Belgian residential care facility with a local service and day centre for people with dementia. The Walnut Park organisation aims to transform and extend its existing complex of historical buildings in a park setting. The project was launched through an open tender organised by the Flemish Government Architect's Team for innovating care projects. At the time of the study, studio:ratio, in collaboration with a British firm, had won the competition and completed the preliminary design.

The data for this paper originate from qualitative interviews and document analysis. Two semi-structured, in-depth interviews of one hour each were conducted with the two studio:ratio architects who were mainly working on the project, namely, one of the partners, Philip, and a younger project architect, Lucas. These interviews were audio-recorded and transcribed verbatim. An informal introduction about the project by David, the other partner at studio:ratio who was also involved, was documented in field notes. In addition, design materials (e.g., client's vision statement, project definition, architects' declaration of intent, competition entry, preliminary design report, …) were collected.

The thematic analysis was guided by the research question "how do architects know about users?". This paper specifically focuses on findings relating to the earlier mentioned results of the ethnographic case study about a person with early-onset dementia, which the architects adopted in their design. This focus allows analysing the potential of an ethnographic case study to inform architectural design. Insights are constructed by triangulating findings from the various data collection methods. All quotes below have been translated by the authors.

[221] For reasons of confidentiality, the names of the firm, project and architects are all pseudonyms.

4. Results

4.1 Contextualisation

> "*(almost whispering)* We actually don't know what a residential care facility should be like. If you're very honest, we just don't know. And we don't know what it's like to grow old, and we can't imagine either." (Philip)

This sincere statement by Philip, the partner at studio:ratio in charge of the Walnut Park project, illustrates architects' current situation: architects (even those with experience in designing residential care facilities) acknowledge not having access to the experiences of people with dementia. Nevertheless, numerous scientific studies have been conducted about dementia. Although these resulted in various recommendations, the architects could not find integral guidance relevant to their domain, i.e., organising space. Low applicability and high specialisation of information easily puts architects off:

> "I decided for myself rather quickly that I wasn't that interested, because I presumed or noticed that [recommendations are] always about very small [details]. *(reciting)* People with early-onset dementia have exit-seeking behaviour, which means that banisters shouldn't be one meter high but that you'd better make them a bit higher. Older people, people with dementia, have a different perception of colours, which means that you shouldn't make a black and white chequered floor. . . . A *real* effect on the architecture and the organisation of the plan [these recommendations] didn't have." (Philip)

Alternatively, the architects drew upon sources closer to their domain. Current architectural discourses set out by the Flemish Government Architect's Team provided a frame to take on the design. For instance, the architects picked out the themes of "small scale" and/versus "large scale", which were linked to their personal approach (see below).

The architects' design was also largely informed by their own experience and architectural capital. This includes the skill to explore spatial experiences in physical models, personal collections of architectural references, and the development of personal themes in their repertoire. To illustrate the latter: in a previous design, Philip had started working on the spatial concept of circuits or networks to introduce hominess (cf. small scale) into a large scale residential care facility. Yet, with dementia, central to the Walnut Park design brief, the studio:ratio architects did not have any personal experience.

As is characteristic to the competition format, the selected architectural firms were expected to develop a design proposal with hardly any dialogue with the client during the competition stage. Architects were provided with a short vision statement by the client and an extensive design brief developed by an external consultancy firm. This brief did not really respond to studio:ratio's expectations. For instance, the architects found it difficult to work with abstract concepts such as "hominess", which can have different meanings to different people. They would have liked to see more concrete requirements and an explanation of the client's way of working. Moreover, they criticised the way the brief proposed particular architectural solutions, which felt imperative and putting them out of the job as architects. As a result, they had difficulties in finding their own approach.

At this point in the design process, they had contact with an architectural research group about some ethnographic case studies on living with dementia this group conducted.[222] In the interviews, this contact and one of the scientific articles were identified by the architects as a turning point:

> But what made a great shift was a conversation with [a researcher]… and a number of articles she sent us about people with dementia. There was one article . . . about a lady with early-onset dementia who described . . . how she started looking for places in her reduced world and how she experienced the world and the home environment. And it was very much about a scale-down, about very small elements, such as . . . *my* chair, with *my* table beside, with *my* pictures of *my* children that are always in that place, and *my* books and *my* lamp, [which] become very important. Or *that* spot in the kitchen since I'm always sitting there because *that*'s where the sun enters in the morning . . . Suddenly spatial experience is no longer related to what we call architecture but to very intuitive things, memories, or… simple things such as feeling the sun on your face. And that made us believe that our network idea could work. (Philip)

This ethnographic case study offered the architects insight into the daily life of a person with early-onset dementia living at home with her husband. This concrete contextualisation of living with dementia was able to change (to a certain degree) their preceding "we don't know what it's like"-situation. It enabled them to acquire a certain understanding of a domestic context that was transferable to the residential care facility context. This had been impossible through the usual sources that informed their design.

4.2 Incorporation

More than just generating an understanding of living with dementia, the ethnographic case study also facilitated architects' concept development in their design of Walnut Park residential care facility. The study and accompanying article about Mary, a person living with early-onset dementia, proposed the concept of "little worlds". This concept describes Mary's tactic to claim and control certain places in her living environment as a reaction to her experience of disorientation. The architects on their part were, based on their intuition and experience, working on a spatial concept to introduce hominess into the larger scale (as mentioned before). From their particular point of view, they were able to interpret the article's central concept of "little worlds" and couple it to their architectural campus/network concept. In this way they could consolidate their concept:

[222] The contact persons were the last and second author of this paper. The contact was in the context of studio:ratio's competition design for Walnut Park, and studio:ratio requested background information on dementia. The researchers first sent them the article about the ethnographic case study of Mary (Van Steenwinkel, Van Audenhove and Heylighen 2014), without further guidance. After studio:ratio won the competition, they also had a meeting on designing for people with dementia, and the researchers provided them with additional scientific articles. At that time, the study reported in this paper had not been initiated.

> “The Care Campus offers a third way that combines the best of both worlds [i.e., of small scale and large scale]. This concept has the aim to maximise the living environment of the resident with a care need. The [resident’s] spatial experience and feeling of 'home' are not necessarily based on the classic image of a defined house but rather on the identity of the place, objects, activities and people. Rather it is a person’s ability to choose his favourite place, to define it and model it to his wishes, which generates a sense of home. This model of perception corresponds very closely to the idea that one can feel fine in several places and that the [resident’s] personal experiential world rather consists of a network of little worlds than of the need to isolate oneself in a separate house.” (studio:ratio’s competition entry)

The particular strength of the ethnographic case study is its potential to be related to and strengthen the architects’ “gut feeling” (Philip), on which they rely throughout the design process. They seamlessly integrated the architectural and research concepts into one new concept of “a network of little worlds”.

Whereas the design suggestions from the design brief had narrowed down architects’ solution space to a point with little room for manoeuvre, the “little worlds” concept allowed opening up possibilities again. The concept’s generativity made it particular useful to architects, as it allowed framing and evaluating design issues on different levels. On the level of the private room, e.g., attention was paid to opportunities for the residents to furnish and personalise their own room in order to support identification. On the level of the collective living unit, circulation areas consist of living rooms instead of corridors – in line with the typology of a mansion rather than an institution. Also on the level of the campus, the local service centre and park garden offer a protective environment as well as a connection to the neighbourhood. The architects aimed to enable residents to appropriate “little worlds” at each of these levels in the campus network, so that “those different places together mentally start becoming your house” (Philip).

The perspective generated by the “little worlds” concept also provided a frame for studio:ratio to study and evaluate (elements of) other architects’ design projects. As observed, it is common practice for architects to critically use these as references to inform their own design. The example below illustrates how the concept orientated architects’ perspective:

> “In the context of a team excursion, we visited all kinds of residential care facilities. It was very fascinating [to think about] how architecture . . . relates to its residents, and how that spreads a kind of atmosphere. And [to analyse] how small gestures can offer some kind of small scenes or benchmarks. For example, in the [private] rooms [of one of the facilities we visited, you would have a typical] entrance area and a small bathroom and a closet. But there was a sink incorporated in that closet, so that every resident, in his own room, is able to take some water from a kitchen tap and make some tea. And so, I *never* thought about it, but it was *such* a nice feeling, like, “this is also a bit of an apartment, your room”. And that related very closely to our idea of “little worlds”, of different scales. Namely that everyone has their own apartment but that apartment is contained within a larger apartment, and that larger apartment is contained within a larger building. So the idea of such a small sink can make that idea stronger.” (Lucas)

4.3 Expression

The previous section showed how the main concept of "little worlds" from the ethnographic case study lend itself to a spatial translation by the architects because of its link with (their core business of organising) space. The case study also enhanced adoption by offering a clear selection and identification of a concrete concept – namely, "little worlds". Studio:ratio adopted the name "little worlds" in their own narrative. This identifiable, solidified concept could be easily picked up by other parties. Thus, although the case study was interpreted by the architects and translated to a new design situation, the name expressing the concept was still borrowed from the original scientific source.

The "little worlds" concept was also suitable to be expressed visually. Figure 1 shows the drawing David made to explain their concept for the Walnut Park project to the client and other jury members. The accompanying text in the competition entry states:

> "The 'mental map' . . . shows a potential image of the world of a resident at the care facility. Small things become more important than big ones. The drawing shows a network of 'little worlds', a fascinating and rich care campus." (studio:ratio's competition entry)

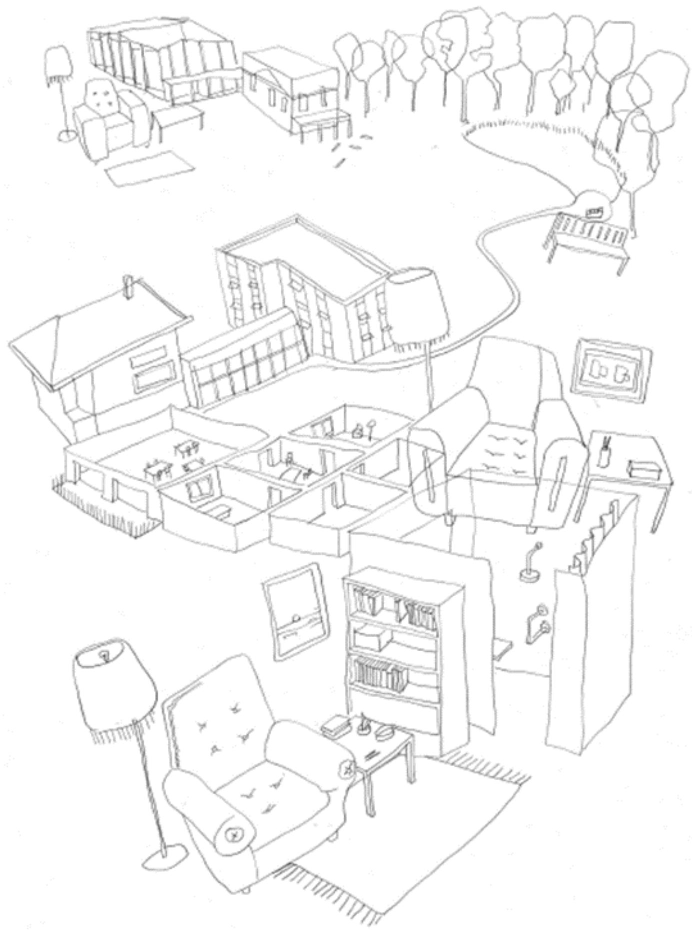

Figure 1 This drawing expresses studio:ratio's concept of "a network of little worlds". It became a visual reference to the Walnut Park project. © the architects

The foreground shows a scene with a chair, lamp and side table with personal objects, which is consistent with one of Mary’s “little worlds” described in the scientific article. Adjacently, a sanitary unit indicates that the scene is situated in someone’s private room in a residential care facility. The drawing then unwinds in a chain of “little worlds”, where similar chairs appear in different settings on the Walnut Park care campus, and even a bench in the park. Although not accurate in a geographical sense, the drawing identifies buildings and spaces on the campus. By shifting the perception of the site, the drawing alludes to people with dementia’s difficulties in orientation. The architects’ concept of focussing on places with a meaningful identity is as such visually presented as a design strategy.

Although the drawing’s primary purpose was to enable communication with the client, it also played an important role in studio:ratio’s internal communication. For instance, the drawing also formed the basis for the partners to inform Lucas on the concept that was going to steer the project’s further development. So although the drawing (like the concept) was not collaboratively constructed by all architects working on the Walnut Park project, it did have a shared function in the design process.

The drawing that expresses the “little worlds” concept even acquired an own identity. It became a visual reference that symbolises the Walnut Park project, more or less like a main conceptual scheme or an iconic photograph would do:

> “This is really a drawing we didn’t just use for the competition but that’s afterwards still being referred to as “that little worlds drawing”, that’s what this project is.”
> (Lucas)

5. Discussion

A limitation of our study is that the design for Walnut Park has not been realised yet. Within the scope of this study, we therefore cannot make any claims about whether adopting the results of the ethnographic case study on living with dementia resulted in an environment that contributes to people with dementia’s wellbeing. Furthermore, the results in this paper are largely based on retrospective interviews with architects, which have the risk of presenting the design process in a diverted way (Lawson 1994, p.2). This risk was minimised by triangulating the interviews with an analysis of design materials and with observations in the architecture firm, which provided an understanding of how the architects work.

The architects’ adoption of the results of an ethnographic case study in the particular format of an academic article was not obvious. Given that design practice is characterised by an intuitive approach and high time pressure, designers are found to absorb information in an opportunistic way, cherry-picking from all kinds of sources and fields, but to be reluctant to read long academic texts (Kornberger, Kreiner and Clegg 2011; McGinley and Dong 2011). Of course we cannot generalise from this case that (in contrast to what other researchers found) a scientific ethnographic article works for architects in any case. Maybe it was the accidental cherry that was picked. Maybe it was a matter of perfect timing. Maybe it was the additional personal contact with the research team (cf. Kirkeby, et al 2015). Nevertheless, the format must have contained crucial elements for knowledge transfer.

To return to our research question, we certainly can learn from analysing architects' adoption of the ethnographic case study in their design. We can state that the case study's main concept of "little worlds":

- served as a breakthrough when architects were stuck in defining the design problem, by providing insight into living with dementia transferable to this problem;
- then served as a vehicle to design a consistent project, by facilitating the development of a concept that allowed framing design decisions at different levels of the design;
- and lend itself to a convincing expression, both verbally and visually, in both internal and external communication.

These contributions span the three activities of "delimiting the solution space, defining an organizing theme, and choosing a communication strategy" that typically structure architects' work when preparing a competition entry (Kreiner 2013, p.226). This thorough implementation indicates an effective knowledge transfer from research into design practice.

In terms of the first contribution – providing insight into the problem – the suitability of case studies, which offer contextual, transferable knowledge, has been well-argued (Flyvbjerg 2001; Kirkeby 2009). What makes the ethnographic case study different from, say, a documentary (which can also provide insight into the daily life of people living with dementia) is its presentation of a clear concept with spatial relevance.

This concept is abstracted to a certain level but still refers to a person with dementia's personal experiences and concrete situations. This allowed the architects to crystallise their thoughts on their network concept-in-development. Thus, the ethnographic case study's second contribution consists of facilitating the development of a manageable concept to tackle the design problem. The importance of a generative concept for the design has been well-documented and conceptualised (cf. Darke's (1979) "primary generator", Rowe's (1987) "organising principle" or Lawson's (1994) "concept"). Architects are found to devote much effort to the quest for such a generative concept, which provides a rationale for their design decisions:

> This central organizing principle, this grand narrative, this Archimedean point from which everything can be derived and to which everything can be referred is important in two ways. It fosters *consistent design* and it facilitates *convincing communication* of the design proposal to even the lay members of the jury. (Kreiner 2013, p.231)

In particular, the "little worlds" concept in this study provided architects with a spatial element around which insights about living with dementia can be grouped. Such explanatory concepts have proved valuable building blocks in design. For example, Lynch (1960) identified five elements – path, edge, district, node, and landmark – as clues to urban design. Coming back to the information characteristics identified in the background section (Van Steenwinkel 2015), we can indeed observe how exactly the *open-ended-* and *descriptiveness* of a *condensed* concept, offering insights into the *daily life of a person with dementia* as well as being *relevant to designing space*, turned the “little worlds” into a building block for architects in their design of a residential care facility for people with dementia.

The architects indicated that they would probably have developed a similar design based on their own intuition, since they were already working on a network model as a spatial concept. Some might see this as weakening our argument, but we argue that this potential integration with an intuitive, spatial approach might be the very success factor of the ethnographic case study. By adding to the creative problem framing – essential in the co-evolution problem and solution (Dorst and Cross 2001) – the resulting concept was well-informed and reinforced. Architects worked with the concept more or less like they naturally use metaphors in design. Metaphors do not just refer to visual characteristics but also to abstract or symbolic ones, providing ambiguous knowledge that “informs all the stages of thinking a building as well as the language to discuss it” (Caballero 2013, p.3).

The architects’ appropriation of the concept deserves some more attention. If we focus on expression (the third area of contribution we discussed), this is also where architects’ own input is crucial. Visualising the concept was architects’ merit. Note that drawings play an active role in the design process (in general). On the one hand, the act of drawing is a way to produce knowledge in architectural practice, by discovering relations (Kornberger, et al 2011) and analysing the drawings’ “back-talk” (Schön 1983). On the other hand, drawings function as “boundary objects” (Bucciarelli 2002) in external communication (Ewenstein and Whyte 2009), for example with the client or jury.

We thus observe not only a contribution of the ethnographic case study to architects’ design, but a real trade-off between academic research findings and professional architects’ skills. If architects’ active participation in analysis and translation turns out to be essential in their effective uptake of research findings, as this study suggests, this should be taken into account in addressing the issue of transferring knowledge from research into practice. It implies that effective transfer not only depends on the characteristics of the information (e.g., including visuals). We might need to rethink the strict division between researchers and designers, for example through formats that allow leveraging the potential of architects, such as their communicative skills (cf. Dankl 2015; Kasalı and Nersessian 2015).

6. Conclusion

This study started from the observation that difficulties in transferring scientific knowledge into architectural practice should be tackled in order to support architects in designing inclusive environments that promote wellbeing. In this paper we investigated the potential of an ethnographic case study to inform architects’ design process through offering a more prominent position of user perspectives.

An ethnographic case study might be regarded an atypical approach to introduce users’ perspectives into design, compared to direct user participation. Yet, based on our findings, we argue that it can be a valuable way to mediate knowledge between two worlds (i.e., people with dementia and architectural practice) with boundaries that are difficult to cross. The architects' conceptual drawing, e.g., illustrates the transformative character of the knowledge embedded in the case study, from the person with dementia's involvement in the research to the architects' active adoption.

More precisely, our results indicate that an ethnographic case study can offer architects insight into the daily life of a person with dementia that are transferable to a new design situation. Moreover it can facilitate architects' concept development. The architects' resulting concept proved valuable to frame design decisions and develop a consistent design, while its visualisation played a significant role in internal and external communication.

Our study contributes to untangling important aspects in informing architects about future users that are difficult to access. The ethnographic case study offered the architects concrete and contextual information, rooted in empirical research, as well as relevant to designing space. Moreover, it provided a clear concept that could tie in with architects' intuitive approach. The architects appropriated the concept in their design. By engaging their own skills, they generated design knowledge, translated, operationalised and visualised the concept successfully.

This trade-off raises questions regarding researchers' and designers' roles in transferring knowledge. The ethnographic case study in this paper is a format that lead to effective knowledge transfer by being receptive for architects' contributions. Yet, more research is needed on how architects in action work with different information formats. Insight in this way of working is expected to support the development of design-oriented formats to inform architects about people's spatial experience.

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Bonding through Designing; how a participatory approach to videography can catalyse an emotive and reflective dialogue with young people

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Abstract: Young people at risk of failing through the educational-net post compulsory schooling, or who have done so already, are too often subsumed under negative-based rhetoric such as disengaged, disaffected, and NEET (Not in Education, Employment or Training). This rhetoric suggests that young people are responsible for their, supposedly, demobilised capacity and fails to acknowledge the fundamental adversities highly disadvantaged young people can face, further camouflaging the most vulnerable. In this paper I reflect on my experience of collaborating with a group of young people, identified by their schoolteachers as vulnerable and at risk of nonparticipation. I reflect on my incremental approach to building and sustaining research bonds, and the catalysing role creativity played. By transporting the technique of Direct Animation into a participatory design context, the participants produced metaphorical videography exploring their ambitions, motivations and anticipations for the future; a conduit through which they explored, translated, and narrated their experiences.

Keywords: youth; vulnerable; participatory; bond

1. Introduction

In this paper I outline how I have integrated my participatory design practice in my doctoral study to better understand factors that mobilise young people's sense of agency in terms of their future societal participation post compulsory education. I position this work contextually before I critically reflect on my incremental approach to building and sustaining a research relationship with a group of young people identified by their school teachers as at risk, and the catalysing role creativity played. By transporting the technique of Direct Animation into a participatory design context, my aim was to create a safe space and conduit through which the participants could explore, translate, and narrate their experiences and stories (McAra forthcoming 2016). Using this collaborative mode of filmmaking, I describe how the participants produced metaphorical videography exploring their emotional experiences of education. I conclude by setting out some initial findings and methodological insights, nuances of which I believe could resonant with other practitioners and researchers interested in the field of participatory design and youth engagement.

2. Situating the Invisible Vulnerable

The Scottish Government (2015) has predicted that approximately 21,000 Scottish young people aged between 16 and 19 are not in education, employment or training, and has ascribed to them the non-participative and stratified label of *NEET*. Characteristically, this group can include young people who are: young carers; care leavers; those with additional support needs such as a disability; ethnic minority groups; asylum seekers; those with a long term illness; young offenders; low-income family households; living in deprived areas; young people suffering drug or alcohol abuse; and teenage parents; gap year students; young people volunteering; or taking a break from work or studying (Scottish Government 2015; Thompson, Russell and Simmons 2014; Furlong 2006; Scottish Executive 2005).

Fergusson (2013) calls into question the shifting political discourse underpinning nonparticipation, as in the case of the *NEET* phenomenon. Rather than tackling the causes of social exclusion and marginalisation, the onus is now placed on the individual through the use of such political rhetoric as *disengaged*, *disaffected* and *underachieving*. Fergusson argues that the application of such language "…constructs them as individualised authors of their own (mis)fortunes" (2013 p. 20), suggestive of nonparticipation as a choice to be rectified through initiatives that increase engagement and integration through participation. Rationalising the *NEET* phenomenon by holding young people responsible for their, supposedly, demobilised capacity, fails to acknowledge fundamental contextual factors and circumstances. In line with Fergusson, I argue that the use of such connotatively loaded rhetoric, which forefronts agency as opposed to the adverse structural circumstances precipitating young peoples' nonparticipation, is furthering marginalisation through a culture of blame.

In addition to its deficit-based connotations, Nudzor (2010) (as well as Simmons, Russell and Thompson 2013; Finlay, et al 2010; Spielhofer, et al 2009; Furlong 2006; and Yates and Payne 2006) problematises the semantics of the *NEET* acronym as over simplifying a multitude of individual traits and circumstances. As outlined by Furlong, et al (2003), a more comprehensive understanding of how agency, combined with external factors, conditions and available resources, is actualised and harnessed is required in order to establish more effective pro-participation interventions. Researchers such as Levitas, et al (2007), Nudzor (2010), and Whittaker (2010) call for far more inclusive and participatory platforms of representation, empowering a demographic that have been synthesised under negative label, situating young people at the centre of research processes about them. Sweenie is critical of quantitative and arguably generic information about *NEETness* as underplaying the diversity of this demographic. In her words this is:

> "…limited with respect to the understanding of individual experiences, perceptions and aspirations compared to the rich primary data potentially available through engaging in purposeful conversation with these young people" (2009 p. 37).

A top-down political system inevitably adopts outside-looking-in approaches, researching to inform policy reform and service intervention. Recent sociological research has attempted to reverse this; conducting research through a more micro-level qualitative lens, laying emphasis on the point of view of those actually experiencing such reforms and interventions. However, a number of key methodological and ethical challenges have been identified by those researching such a fragile and transient demographic (Harkins and Egan 2013; Nudzor 2010). Official *NEET* statistics, which are assumed to measure accurately levels and patterns of vulnerability, bypass those who, because of their vulnerable circumstances, are forced into insecure, unsteady or unsuitable employment or training, where they are at increased risk of exploitation, job dissatisfaction, unstable and/or poor working hours, and low levels of pay (Furlong 2006, p. 565-566). Young people in this situation, viewed as having made a successful transition, become excluded from pro-participation interventions. So much focus on making positive transitions and "chasing targets" (Yates and Payne 2006 p. 331) fails to acknowledge those who either have already transitioned but into poor working conditions placing them at increased risk of becoming *NEET* in the future, or those of a pre-transitioning age, still at school but under pressure to leave early or are disenchanted by a perceived lack of opportunities (Nelson and O'Donnell 2012). These groups, the *invisible vulnerable*, are at risk of falling through the net of care.

Whilst attempting to contextually define the term *NEET*, I have grown frustrated with its generic and arbitrary measurement of vulnerability. As Furlong calls for "…new ways of capturing vulnerability that go beyond NEET" (2006 p. 567), I seek to explore how my participatory design practice could creatively respond to the needs inherent in the methodological challenges researching 'invisible' vulnerable youth, seeking to reinstate and empower a fragile agency, which has become over-simplified, generalised, or perhaps lost entirely.

3. Participatory Design

Unlike traditional forms of design, which typically situate creative authority with the designer, participatory design enables non-designers and the designer to enter into reciprocal dialogues to facilitate and achieve mutual understanding (Broadley 2013; Broadley and McAra 2013; Sanders and Stappers 2008; Simonsen and Robertson 2013). Participatory design can be viewed as a creative discourse of collaborative learning, underpinned by a democratic ideology built upon the socio-political Scandinavian workplace interventions of the 1970's (Simonsen and Robertson 2013). With the status of the *expert* distributed amongst the collective, participants enter into collaborative partnerships with the designer as a dexterous expert of their own indigenous knowledge and “experience domain” (Sleeswijk Visser 2009 p. 5).

So to develop the construction and exchange of knowledge, the use of creative tools support the designer in achieving empathic and contextualized accounts, enabling non-designers to articulate and externalize abstract, often tacit, subjective, experiential and emotive concepts such as identity, values, culture and sense of agency. Working visually, and often taking theoretical and methodological inspiration from disciplines such as sociology, psychology, philosophy and fine art (Koskinen, et al 2011; Sanders 2002; Swann 2002; Zimmerman, Stolterman and Forlizzi 2010), participatory design has an innate ability to stimulate collaborative modes of thinking and communication, whereby a shared language is fostered that traverses disciplinary and hierarchical boundaries (Sanders, 2002). Such a visual dialogue bolsters the egalitarian nature of a participatory design discourse, thus providing a legitimate paradigm for staging research with disempowered demographics through positioning them at the centre of the research, as is the case with this present study.

4. The Setting

My fieldwork took place over a fourteen-month period in a Scottish high school located in an area known for high levels of poverty and deprivation. The fifteen young people I collaborated with were aged between fourteen and fifteen and in a Prince’s Trust a class, completing their Youth Achievement Award. (The Prince’s Trust is a UK wide charity that supports young people in education, employment and training.) This award provides an alternative means to gain a qualification (certified by the Scottish Qualifications Authority), with a curriculum based on activities that will enhance softer skills through additional support such as teamwork, leadership, self-esteem and confidence. This is a two year course with five classes a week, replacing time the participants would have spent in a social subject studying at National Three, Four or Five level (equivalent to the now obsolete Scottish Standard Grades).

The overarching methodological approach of this study was Participatory Action Research (McIntyre 2007; Reason and Bradbury 2006), implemented through a single case study design (Stake 1995; Yin 1994). Reflecting the unpredictability of the context, the fieldwork remained highly explorative in nature, using an emergent methodology that was responsive to the insights that began to surface. I entered into the fieldwork with a loose plan of implementing four methods but was keen to allow the participants and my own intuition to guide exactly when these should be implemented. The four methods were: observation; design workshops; paired and group interviews; and an activity-based focus group. This paper focuses in particular on the first and second of these methods. All names have been changed to protect the participants’ identity.

I was invited to attend the class for a double period (1 hour 50 minutes) on a weekly basis, which allowed me crucial time to leave the fieldwork setting and reflect on what had occurred in the classroom that day through writing up extensive field notes (my main mode of documentation). This iterative process not only enabled me to reflect critically on what was emerging but also was beneficial during the more applied methods phase (the design workshops and interviews) where I also able to hone my approach and facilitation style in reaction to how it was being received.

5. Contextual Immersion

By way of orientating myself within the context, I immersed myself in the classroom for a period of four months. Whilst at the contextual coalface, my aim was to establish trust with the pupils. How exactly this was going to come about, I was unsure, but I was aware from the outset that the pupils would require time to *figure me out* before any authentic rapport could occur. During this period, the teacher and classroom youth worker enthusiastically encouraged me to join in with their lessons through assertively engaging with and offering assistance to the pupils, particularly during the more creative activities. This presented me with an opportunity to also gain the trust of these two gatekeepers through providing them with additional assistance.

This initial interaction with the pupils was, however, strained and awkward. I too was finding my feet in this situation, overcoming apprehensions, and building up my own confidence in striking up informal conversation with them (McAra forthcoming 2016). Attempts to engage in dialogue were frequently shunned or in many cases ignored altogether. Upon reflection, I started to question whether the pupils' general apathetic response to me was perhaps because they found it difficult to work out where I fitted into the authoritative hierarchy in the classroom, and thus were uncertain about how to behave and conduct themselves around me. I was anxious to persevere in my attempts to engage with the pupils, feeling that as I was the outsider, it was my responsibly to do the legwork. However, more often than not such perseverance was not reciprocated. Overcoming this required me to relinquish control and allow the pupils to determine when they were ready to engage and when they wanted to invite me into their dialogues and interactions.

Towards the end of this of phase, the pupils were presented with the opportunity to take part in an inter-school design competition. Although the topic of the competition was not directly related to my own research, I was allowed to participate by helping the pupils interpret the brief, brainstorm ideas and prototype their concepts. Being able to participate in this, now shared, experience was in fact an incredibly valuable way for me to begin to build up this notion of rapport with the pupils. The competition, although unforeseen and fortuitous, enabled this period of immersion to end with me having something in common with the pupils, a shared point of reference with which to enter the next phase of fieldwork (McAra forthcoming 2016). In the same context of conducting participatory research with *at-risk* youth, Wearing (2015) refers to this approach in action as cultivating an "experiential bond" between the researcher and participant. Unpacking this relationship further Wearing outlines that:

> "… the researcher and the researched are co-present and co-learn in their knowledge and relationship building through the research… such an ethics entails a shared authenticity, inclusiveness and empathy on the part of the researcher and participants that promotes care, respect, justice, equity and understanding in the qualitative research process… [it] is to "bond" with the worlds of the "other"… The experiential bond is a more complete, sustainable and longer lasting legacy than simply the activities of research over a given period." (2015 p. 65-68, original emphasis)

Wearing suggests such a relationship is based on a reciprocity that goes beyond the ability of research methods to foster. Building upon Wearing's notion of the experiential bond in the context of the competition, I felt that through collaborating with the pupils in undertaking this experience together, sharing in their work, anxiety, excitement and celebrations, I was brought, if only a little, more into their life-worlds, as they were into mine.

6. Participatory Filmmaking

My aim for the second phase of fieldwork was to engage with the pupils more directly in a creative project as collaborative participants, to explore more directly themes stemming from my research question on young people's aspirations, motivations and anticipations for their future, post compulsory education. In the same vein as Wilson and Milne (2013) who, when conducting research with young people, described the need for methods to be culturally meaningful, I sought to evolve a visual style and form that would be novel and exciting for the pupils, exploring the method of Participatory Video (Gauntlett 2007, 1998, 1997; Lomax 2011; Lunch and Lunch 2006; Milne, Mitchell and De Lange 2012; Shaw 2012; Yang 2013). As well as being ethically concerned about the implications of using real-world footage in this context, I wanted to provide the participants with a medium that allowed them to go beyond the frame of a camera, to use their own imaginations to engineer creatively any possible vision and expression through drawing. In comparison to the use of technological devices, Literate argues that:

> "… drawing is significantly more generative…because one has to actually draw the world into existence, and not merely select aspects of the external environment to record in a video or a photograph." (2013 p. 12)

Furthermore, Heyes highlights the physical bodily activity of drawing, as explorative:

> "… thinking-in-action… a particular mode of thinking that goes beyond, or before, ideas in words… [not beginning] with a pre-determined image, but brings the work into being through an intimate and complex relation between the drawer and the drawing." (2010 p. 18 and p. 139)

As opposed to the immediacy of a (video) camera-produced image, drawing demands a deeper mode of engagement with the medium. The intrinsic time for reflective conceptualistion, reinterpreted by the hand, creates a visual depiction capturing the thought processes of the drawer (Gauntlett 2007), who has intuitively entered into a reciprocal dialogue with the self and artifact. Schön (1983) explains that this auto-dialogical transaction is a cycle of response, reaction and reflection, suggestive of how tacit knowledge can be externalised through such action.

In order to retain the kinetic quality of film, I wanted to test how participants' drawings could translate into a moving image, or more formally to test the method of Participatory Video as an animation or video collage. Inspired by the pioneering works of Len Lye (1935-1980), Norman McLaren (1933-1983), Stan Brakeage (1961-2003) and Man Ray's *Rayographs* (1923-1929), Direct Animation is a technique whereby illustrations are made directly onto the surface of clear, black or recycled celluloid film, which is then projected through an 8mm, 16mm or 32mm reel-to-reel projector, projecting film at approximately 24 frames a second. Examples of materials and tools used on the celluloid include: marker pens; inks; bleach; nail and other types of varnish; dental tools for etching; and stitching by hand or with a sewing machine. This technique, as opposed to more conventional forms of animation such as hand-drawn, cut out or stop motion, allows for the rapid production of imagery without the need for highly repetitive actions. This technique also affords the creation of highly abstract imagery, requiring participants to translate their ideas conceptually through metaphors and connotations, working in shapes, colours and textures.

7. Workshops

Through weekly workshops, the participants learned how to use these various treatments and created a series of collaborative experimental films. After demonstrating techniques to the pupils at the beginning of each session as a form of master-class, I intentionally left all materials out on one desk for participants to then self-select what they wanted to experiment with, encouraging autonomous learning. At times there was a great deal movement and energy in the classroom as pupils left the confines of their desks. Each week I would also screen the participants' work, enabling them to see what types of shapes and textures had the most visual impact, becoming an effective teaching device, as I witnessed the participants quickly develop their skills (see *Figure 1*).

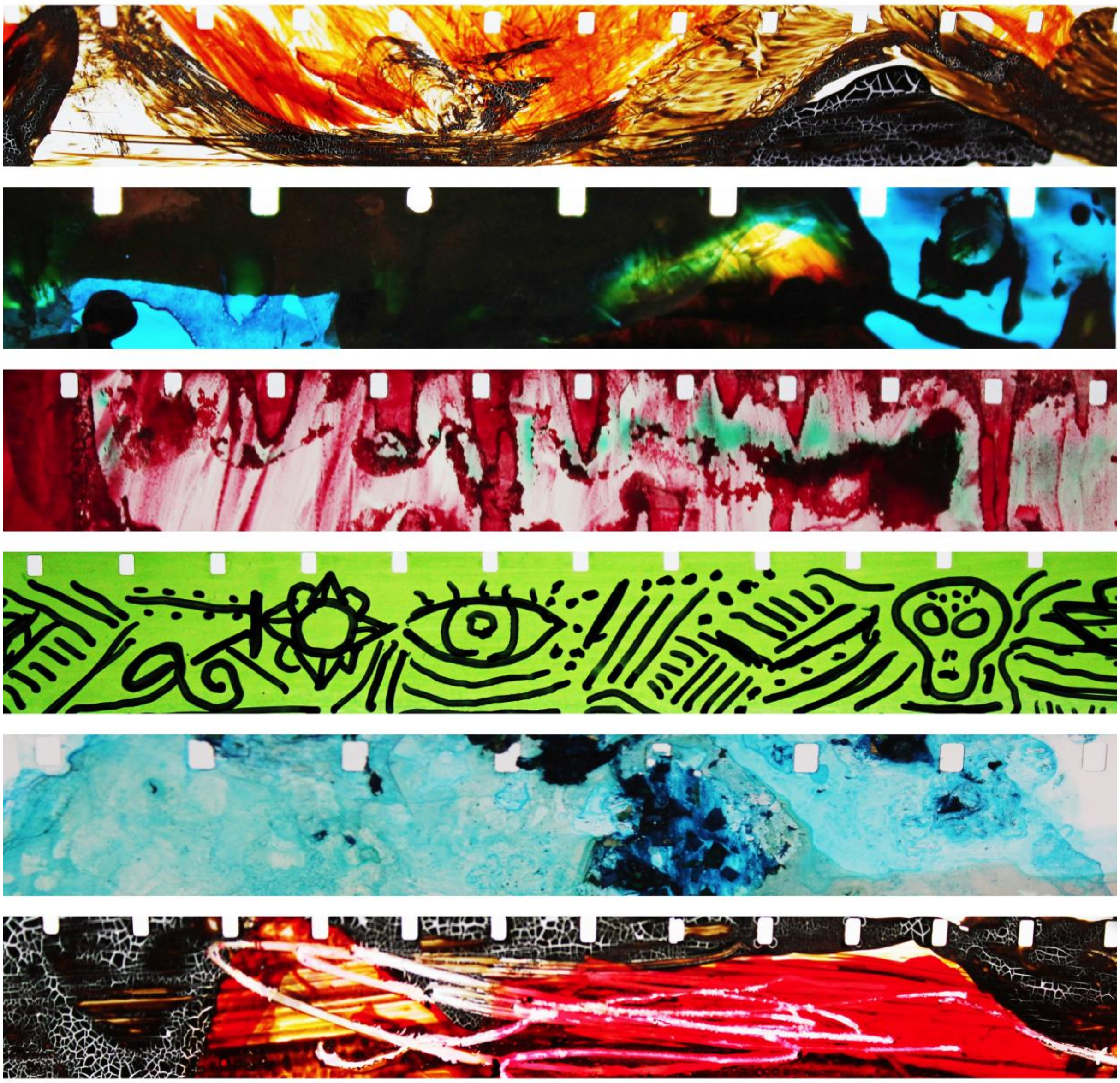

Figure 1 A selection of images created by the participants during the filmmaking workshops

Several critical moments occurred in relation to how the participants reacted and interacted to the workshop activities, particularly in how many responded to its expressive nature. At times when I engaged participants in conversation about their illustrations, whilst enthusiastic about the artistic nature of this approach, I was confronted with defensive disclaimers of their lack of artistic ability. Such self-deprecation was a common occurrence amongst all the participants. In one particular example, Hailey, one of the three female participants, compared what she was doing to a nursery activity. Throughout the workshop, Hailey was eager to experiment with the inks and demonstrate such experiments to me. However, whilst engaged and excited, she assured me that what I was asking her to do was childish “finger painting”.

In such instances, I have found myself unpacking the possible motivations for this self-devaluation. Such downgrading appeared to be instinctually adopted to disguise insecurity and low self esteem, a disparaging strategy that appears to be entrenched within the general culture of the classroom. Paradoxically, describing the activity as infantile actually permitted Hailey to be more fully involved, expressive, and explorative, whilst safeguarding against critique as she attempted to lower my expectations of her skill level. During such moments, I made a conscious effort to remind the participants that their contributions were not being assessed and that the purpose of the activities was for experimentation, and, essentially, they were meant to be fun.

During these early workshops, the teacher approached the group about entering another inter-school competition, this time a filmmaking competition. The brief required us to produce a one minute short about a government sector of our choosing. The participants chose to focus their film on the emotional phases of education. Throughout this time, we had many, quite sophisticated, conversations surrounding the emotive and symbolic connotations of colour and music, where the participants drew up mood boards, music playlists, and a time line tracking the different developmental and transitioning phases of education, from nursery up to high school (McAra 2015). Treating the workshops as a production process, the pupils self-elected roles including Director, Production Manager, Sound Editor and artists. There was a notable shift in the type of participation that took place, perhaps induced by the notion of entering a competition, where I witnessed several pupils' transition from the role of participant to the role of co-researcher. I was struck by degree to which the pupils were identifying with highly abstract imagery and in defining the meaning of colour metaphorically. Emotions connoted through colour included loneliness, hatred, determination, joy and fascination, as well as assigning colours to symbolically represent childhood, innocence, growth and safety (see *Figure 2*).

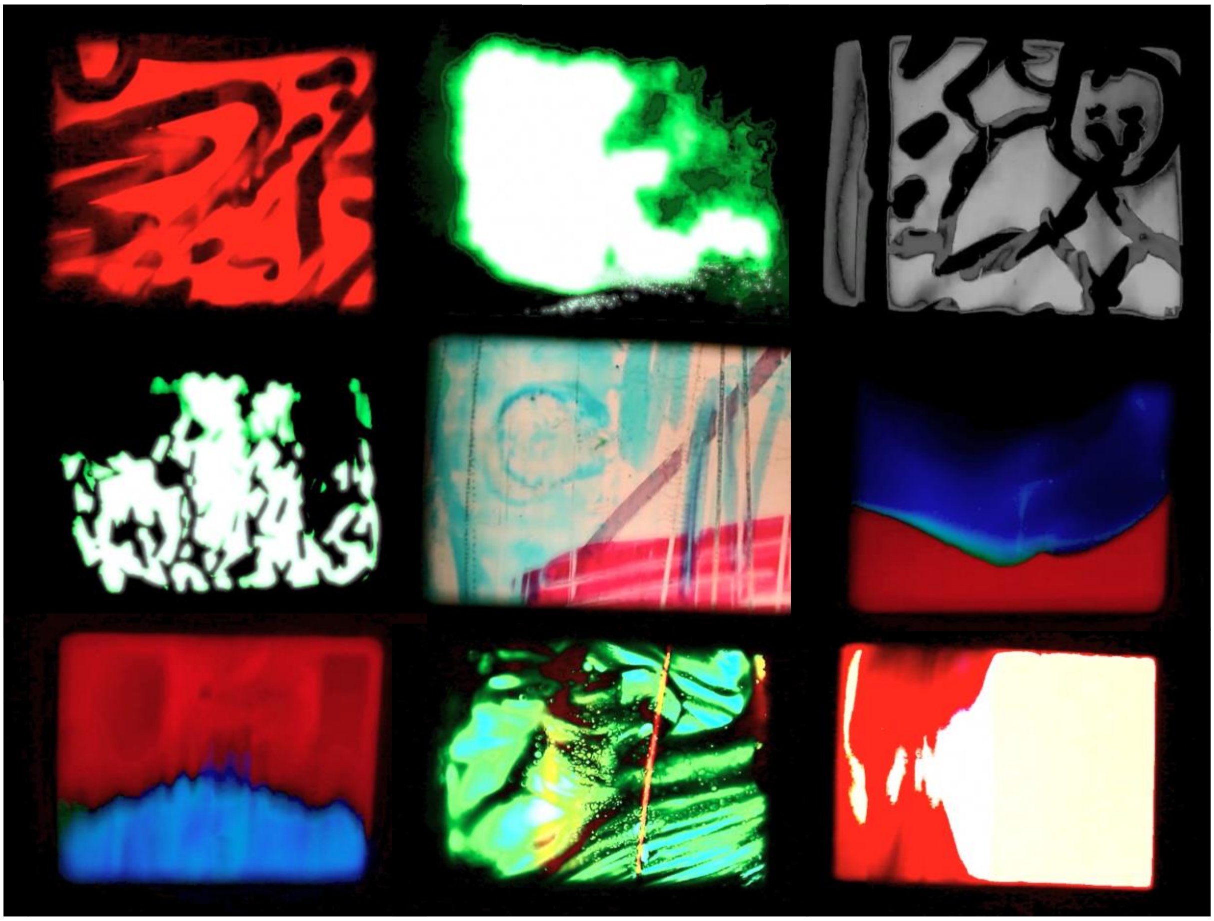

Figure 2 A selection of stills from the participant's final film

8. Reflections

As well as reflecting on how the participants were developing as co-researchers through the filmmaking process, I also became conscious of how my own role was fluctuating. I experienced a fundamental challenge when facilitating collaboration with this diverse group of individuals. I found it a necessity for achieving meaningful dialogue to, like a chameleon, consistently adapt my demeanour and conduct in-line with individual participants on a very bespoke and personalised basis (McAra forthcoming 2016). At this point within the fieldwork my instinct in managing this grew as I had become mindful of the individuals who required a little more guidance and encouragement and of those who had the confidence to assertively take the lead. With those less confident, I took on the role of participant, sitting down next them and taking part in the filmmaking activity, as described in the field note exert below:

> "… I began working on my own piece of film, and together we sat, crafted, and conversed… I began the conversation by asking what they thought they would do after leaving school. Whilst Matt described wanting to get into construction, Lewis and Sam described their thoughts about possibly joining the Army or Royal Navy. We discussed the army and Iraq, where I offered a personal anecdote of a family member's involvement in the army. During this time, the conversation wove in and out of these personal anecdotes and discussion about the film. Sam then began experimenting with

> dipping the film into a cup of ink, taking it out, and drying it very quickly which lead to the film having a translucent dyed effect. Matt used his hands to thickly spread ink onto his film, commenting on the pearlescent, almost metallic effect it was creating." (Exert taken from field note recorded 20/10/14)

Through modelling the technique to these participants, they were able to follow in my footsteps before intuitively deviating away from my examples to work independently. With the more confident participants, I refrained from overt facilitation and advised them as a co-researcher through gently challenging their assertions and helping them with planning and organisation:

> "I watched as this initial interaction unfolded between these two main sub teams – Max, David and Joe focusing on the music and Hailey and Meghan working on the films visual content. They began by positioning themselves at opposite ends of the classroom. Both working autonomously, I suggested that as what they were each doing was going to be informing what the other was doing, they would need to start talking and working as a collective. Dialogue between the two groups ensued loudly across the classroom. Reiterating the fact that both groups needed to work together, Hailey and Meghan picked up their timeline and placed on the floor by the other group working on the computer. This location then became the site of collaborative activity for the rest of the period." (Exert taken from field note recorded 6/10/14)

Underpinning my roles, in both these examples, was the ability to nurture. At times I also became a mediator and advocate in negotiating with the more active participants an invitation for those more passively situated at the periphery, to join them at the hub of activity. This level of understanding and awareness of individuals' working style and character, which allowed for more meaningful interaction, only occurred with time and patience, and on the participants' own terms. On numerous occasions the participants sought individual ownership over specific responsibilities, techniques, and materials, making genuine collaboration challenging to facilitate. Whilst such self-mobilisation was encouraging in terms of harnessing agency, it was also often the cause of conflict and creative tensions, where my role would have to quickly transform to one of peacekeeper and diplomat.

Furthermore, I found it challenging to broker the often conflicting dynamics between the already established and firm classroom hierarchy set by the teacher with the collaborative and democratic culture I was striving to create. I felt at times the teacher inadvertently encroached on the participatory nature of the workshops when she either reprimanded pupils for misbehaviour or forcefully encouraged them to take part. Moments such as these drew my attention to the implications of implementing this study in the institutionalised setting of a school, nuances of which I acknowledge were most likely implicitly embedded in the conduct of the pupils as participants. For the duration of the research, the young people were at once both collaborative partners with me, as well as pupils in a classroom under the supervision of the teacher. In line with Spyrou (2011), who raises concerns over the effects of institutional settings, particularly the ingrained influence of established hierarchical power dynamics young people are subordinated by in the context of education, I too became mindful that the very setting of this research could be at odds with the underpinning democratic values of my methodology. Whilst I felt managing the group dynamics was my responsibility, I leant on the filmmaking process as a means of attempting to maintain an egalitarian culture within the classroom.

9. Findings

Reflecting on the efficacy of Direct Animation as a participatory film medium, I witnessed the process encourage the participants to be explorative, experimental, metaphorical, and highly creative, by working in a medium that does not strictly demand drawing ability. The participants collaboratively constructed a shared visual language completely of their own making, positioning them in control of what, and the degree to which, they disclosed their experiences and knowledge through. Reflecting on, and translating their knowledge and experiences metaphorically into abstract imagery and through the interpreted of music, colour, shapes and textures, the participants' final film was emotive, reflective and profound. In this respect, I draw on Schön's (1984) theory of reflection-in-action, where the participants reflectively interacted with and through the process of direct animation, working within the connotations of their illustrations, as opposed to what was literally been drawn. Here I also draw on Dewy's (1934) notion of how the aesthetic is experienced – drawing on his concept of the Expressive Object. For Dewy, art should be viewed as an expression rather than a direct depiction. In the making of these films, the illustrations were a mode of self-expression rather than of representation or statement making. It was an emotional response embodied and expressed in and through the mark marking.

Additionally, the goal of entering the competition provided a common objective, helping to instil a sense of camaraderie, with the participants treating the process and their roles synonymous to that of a production team. Whilst the analogy of a production process brought about group cohesion, it also heightened autonomy through empowering individual participants to utilise their own newly acquired skills, in their self-elected roles. Created together, the process of making these films became a further opportunity for me to "experiential[ly] bond" (Wearing 2015) with the participants. As a method, the value of Direct Animation is located in the process, as opposed to finish artifact.

The aim in relation to my research question was to discern factors that motivate young people's sense of agency. A key contextual finding was that the participants were able to articulate a deep and insightful knowledge of their desired learning styles and have an acute awareness of the types of teaching activities that enabled and motivated them to learn and equally, the styles that did not. Many described an enhanced experience of learning and enjoyment in classes where teaching was premised on practical activities such as games and experiments, where the pupils were enabled to take a more physically active role in their learning. Within this, the majority of the participants indicated a correlation between didactic styles, their own classroom behaviour, and their relationship with particular teachers. Qualities sought in favoured and, more significantly, trusted teachers included being supportive, compassionate, dependable and nurturing, in some cases described as maternal and paternal figures. The pupils reported that such qualities demonstrated by a teacher would then be reciprocated through being more committed and attentive in their classes. Conversely, teachers less favoured were regarded as untrustworthy, uncaring and unreliable, where often the participants felt a sense of rejection, that they were not prioritized and in a losing competition with other, higher achieving pupils, for attention. In such cases, particular participants described feelings of frustration manifested as an apathetic attitude in these classes.

What became gradually more apparent was this group of young people were dealing with a complex mix of conditions and circumstances, both inside and outside of school. When discussing classroom behaviour, the participants reflected on how personal problems and adversities occurring in their lives outside of school can unintentionally manifest in disruptive and rebellious behaviour in school. Focusing on their goals and aspirations was mobilising the participants' motivation for their schoolwork and assessments, making motivated endeavours for their futures. However, when describing plans for their future post compulsory education, the participants alluded to anxieties about leaving the safety net of school. Several participants described looking forward to having more freedom, however seeking this and fulfilling their goals locally by staying close to home. Others, whilst communicating highly aspirational ambitions, appeared resigned to a despondent and pessimistic outlook, with an underlying inevitably of failure.

10. Conclusion

The entrenched culture of self-deprecation and self-disparagement that I observed in the classroom was suggestive of a somewhat fragile yet resilient personal agency. As I have argued, the young people deliberately masked their insecurities and low self-esteem to lower expectations of their skill level. Paradoxically this functioned as a self-empowering strategy. There are important lessons here for future research investigating at-risk, particularly younger, demographics. My research highlights the ways in which genuine insight can be gained by offering the pupils a creative activity that strived to foster autonomous learning, and to empower the pupils to harness their own agency as participants and co-researchers. Reflecting on how a participatory design approach can catalyse an emotive and reflective dialogue, I suggest the need for a sensitivity on behalf of the researcher to look for cues and seek out opportunities for experientially bonding with participants. With time and patience, these sometimes fleeting opportunities can be built upon incrementally so as to cultivate moments of genuine engagement, and meaningful and authentic dialogue.

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Capturing architects' designerly ways of knowing about users: Exploring an ethnographic research approach

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Abstract: Transferring knowledge about diverse users' experiences from research into architectural design practice is not straightforward. Effective knowledge transfer requires taking into account architects' design practice. This paper explores a research approach to gain insight into architects' designerly ways of knowing about users. It discusses why an ethnographic research approach offers a means to study a culture of practice such as architectural design practice. A fieldwork account from a pilot study in an architecture firm provides insight into the experiential issues architects deal with. It illustrates how fieldwork techniques can be applied to map the socio-material aspects (e.g., different stakeholders and design materials) that mediate knowledge about users. Exploiting these aspects of architectural design practice is expected to open new ways of thinking about informing architects about users' experiences. For instance, there lies an opportunity in engaging architects' creative representational skills, which challenges architects' and researchers' roles in knowledge transfer.

Keywords: architectural design; ethnography; knowledge; research methodology

1. Introduction

Architectural design processes are becoming increasingly complex due to the various requirements (e.g., sustainability, accessibility, heritage value) and the constellation of stakeholders involved (e.g., client bodies, consultants, contractors). Especially in large-scale projects, client and end-users typically do not coincide.[1] Since the industrial revolution

[1] We are aware of the critique on the notion of "users". Yet, for lack of a more appropriate term, we will use this as shorthand for "people who use the building or space whom architects design for".

introduced a dichotomy between design processes and use practices (Redström 2012), the gap between designers' intent and users' actual experience has grown (Crilly, Maier and Clarkson 2008).

Architects are expected to conceive buildings and spaces with an eye to offering people a future experience, often without having access to their motivations, values and experiences. Yet how can an architect grasp what "home" means to people with dementia, or "healing environment" to people affected by cancer? Designing for "the other" is challenging, because others' spatial experience can considerably differ from architects' due to differences in age, gender, ability, ethnicity, profession, situation, etc. (Imrie 2003). A crucial competence for designers is thus being able to empathize with future users (Dorst 2006; Formosa 2009). To this end, architects need sources that inform them about diverse users' spatial experience and needs (Annemans, et al 2014).

Our research aims to address the challenge of transferring knowledge about users' experiences into architectural design practice. As identified by various authors, the knowledge generated by traditional research mismatches the knowledge required in architectural design practice (Diaz Moore and Geboy 2010; Kirkeby 2009; Rashid 2013). We argue that the lack of effective ways to communicate users' spatial experience and needs to architects relates to a lack of attention to architects' "designerly ways of knowing" (Cross 2006) in research methodology. Our overall goal is to develop more effective information formats by tying in with architects' design practice.

Currently, little is known about architects' particular ways of knowing about users. The most obvious methods to study architects' information handling are questionnaires and interviews (e.g., Bogers, van Meel and van der Voordt 2008; Kirkeby 2015; Tétreault and Passini 2003; Weytjens, Verdonck and Verbeeck 2009). As these rely on self-reporting, they risk a diverted presentation of the design process (Lawson 1994, p.2), and provide little insight into how knowledge about users is embedded in architects' design practice. This paper starts from an understanding of design as a process situated in and distributed across a socio-material environment (Heylighen and Nijs 2014). Acknowledging the mediating role of different stakeholders and design materials implies that they should be taken into account when studying architects' designerly ways of knowing about users.

An ethnographic research approach has proven valuable to gain insight into architects' practice (predominantly in social studies of science and organisation studies) (cf. Christensen 2013; Cuff 1992; Ewenstein and Whyte 2009; Kasalı and Nersessian 2015; Kornberger, Kreiner and Clegg 2011; Luck 2007; Yaneva 2009). We argue that such an approach has the potential to provide the kind of results required for our more applied study, which aims at developing design-oriented information formats.

The aim of this paper is to explore a research approach that allows gaining insight into architects' designerly ways of knowing about users. Based on an understanding of design as a socio-material process (section 2), we argue for an ethnographic research approach to study a "culture of practice" such as architectural design practice (section 3). Next, an account from a pilot study in an architecture firm illustrates the application of fieldwork techniques such as participant observation, interviews and analysis of design materials to capture architects' designerly ways of knowing about users (section 4). We discuss how the kind of results generated through these ethnographic techniques allows for an in-depth understanding of the social and material aspects of architectural design practice (section 5). Subsequently, the practical possibilities and limitations of the ethnographic research approach are discussed (section 6). Insights from our study are expected to inform the development of design-oriented information formats to effectively transfer knowledge about users' experiences into design practice.

2. Design as a socio-material process

If our ultimate aim is to inform architects' design process about users' experiences, it is important to acknowledge that "design has its own distinct 'things to know, ways of knowing them, and ways of finding out about them'" (Cross 2006, p.17). An important characteristic is that designers do not conduct extensive research, but address design problem and solution simultaneously (Cross 2006; Lawson 1994; Rittel and Webber 1973; Schön 1983). The particular nature of design in general affects designers' ways of handling information and their preferences concerning its content and type. For instance, designers prefer information that is descriptive and design-relevant, whereas they dislike prescriptive rules or extensive reports (Annemans, et al 2014; Dong, et al 2015; Goodman, Langdon and Clarkson 2006; Nickpour and Dong 2011). The omnipresent standards and regulations are criticised by architects for offering little insight, restricting their creativity and taking away their challenge to come up with intelligent solutions (Gray, Gould and Bickenbach 2003).

Given architects' selective information uptake (Newland, Powell and Creed 1987) attention should be paid to the information format. It is important to understand "information format" in a broader sense than a type of document. Focussing on the characteristics of information only would isolate information from the practice in which it is used. In reality the interrelation between designers and information is more complex. For example, designers can hold certain predispositions regarding information that are not related to the characteristics of the information itself, but rather derive from their status, background or habits (Lera, Cooper and Powell 1984).

Nowadays, designing is increasingly understood as situated in and distributed across a socio-material environment (Heylighen and Nijs 2014). Design is rather a team than an individual activity (Valkenburg and Dorst 1998). Moreover, as mentioned, designers increasingly collaborate with other stakeholders. The way the client translates user needs, e.g., can impact on architects' design process (Van der Linden, Annemans and Heylighen 2016). Attention to users' spatial experience can be facilitated or hampered also by the material context. This includes the design materials used in this collaboration, such as photographs, sketches, physical and CAD-models. Designers reflect-in-action on potential solutions by manipulating design materials and incorporating their "back-talk" (Schön 1983).

Our research sets out to study in depth how architectural design practice attends to people's spatial experience. Contemporary understandings of design direct our research focus to examining how architects' socio-material environment mediates their attention for users. This broadens our perspective from information characteristics to how knowledge about people's spatial experience and needs is generated, shared, transformed and represented. If ultimately we want to develop information formats that tie in with architects' designerly ways of knowing, our research methods should allow taking into account the preconditions set by the socio-material environment in which architects work.

3. An ethnographic research approach

Ethnography is the systematic study of a culture of people, traditionally applied by anthropologists (Boas 1920). The culture we want to study here is not one that originates from a shared ethnological background, rather it is a "culture of practice", originating form a shared professional situation. Architectural researcher Dana Cuff (1992) argues that considering architectural design practice as a culture creates the perfect opportunity for an in-depth examination:

> "Use of the concept of culture fosters a certain kind of analysis, one that looks closely at people's everyday lives, their situated actions, as well as what they say and the meaning they construct. . . . an ethnography ties ideas about the group's knowledge, its beliefs, its social organization, how it reproduces itself, and the material world in which it exists. These guidelines for studying "unfamiliar" cultures apply equally well to those communities that we encounter every day." (Cuff 1992, p.5)

An ethnographic research approach has been frequently adopted in social studies of science, to study the cultures of practice of, e.g., laboratory workers (Latour and Woolgar 1986). Researchers with backgrounds in social sciences and/or design have conducted studies about engineering designers (Bucciarelli 1988; Lloyd 2000; Vinck 2009) and even architects (Cuff 1992; Yaneva 2009). Also organisation and management studies have borrowed from ethnography to study architecture firms (Ewenstein and Whyte 2009; Kornberger, et al 2011). All these studies have adopted the basics of ethnography to capture an insider's view on a particular culture of practice.

Pioneer-anthropologist Bronisław Malinowski (1922/1984) is known as the first to elaborate on ethnographic research methods that allow grasping the participants' point of view. He suggests initially focusing attention on tools, skills and material cultures through careful observation. This may reveal cultural habits and the so-called "imponderabilia" or characteristic details of daily life. In the second instance, he suggests, the meaning of these observed aspects be understood through statements and narratives of participants.

Indeed, as a culture is embodied in "mundane" body techniques, people may find it difficult to explain their commonplace or routine activities. As these activities appear obvious to themselves, or are even taken for granted, they are hard to be aware of. Relying solely on interviews would allow shedding a light on the shared vocabulary, attitudes and values of the culture, but it would render many meaningful aspects invisible. Or as Tony Watson (2011) states in his plea to apply ethnography in organisation and management studies:

> "we cannot really learn a lot about what 'actually happens' or about 'how things work' in organizations without doing the intensive type of close-observational or participative research that is central to ethnographic endeavour" (p.204)

Linden Ball and Thomas Ormerod (2000) point out three reasons to apply ethnographic fieldwork techniques in studying design practice. First, an ethnographic approach takes into account the complex nature of real-world design, which renders experimental research methods inappropriate. Second, it takes into account the social context instead of just focussing on individual behaviour. And finally, it has the capacity to track ad hoc decision making and interactions outside the official realm, e.g., during coffee breaks.

A study of everyday practices as they take place in their own socio-material environment allows paying attention to skills, tools, narratives and commonplace activities. The most important data collection techniques in ethnographic fieldwork are participant observation, in-depth interviews and document analysis. They allow collecting contextualised, detailed, experience-rich data. Assembling observations of architects' everyday ways of working and skills with narratives from in-depth interviews and an analysis of design materials, is expected to produce insights into their designerly ways of knowing. As such we aim to understand how knowledge about people's spatial experience is generated, shared, transformed and represented within architectural design practice.

4. Fieldwork account

This paper reports on a pilot study in a Brussels-based architecture firm, set up to explore the possibilities and limitations of the research approach and produce preliminary results (which will be further investigated in studies of different architecture firms). At the time of the study, the firm consisted of nine architects, including two partners and two interns. The firm's portfolio mainly consists of public buildings and collective housing projects. Many projects are granted through competitions. The first author conducted fieldwork during a six-week research stay in fall/winter 2014, when she was present in the firm on a part-time basis. Her presence was negotiated with the two partners, who stated that "it's nice that someone comes and looks how [architects] work, [in order to] really understand". The researcher's identity was not covered. She briefly presented herself and her aim (to study knowledge in architectural design practice) on the first day.

The researcher was offered a desk in the workplace that was shared by all architects except for the partners. She was granted access to internal and external design meetings and to all design documentation in the firm. She also conducted in-depth interviews with five architects on (knowledge in) the projects they were currently working on. As such, the researcher could observe architects' everyday ways of working (documented in field notes) and complement these with interviews (audio recorded and transcribed) and design materials. Insights were constructed through thematic analysis of the different data.

In this section, four episodes from the fieldwork account illustrate how this research approach allowed investigating architects' ways of knowing about users, with specific attention to architects' socio-material environment. The account focuses on one architect and the main project he was working on. As the design process was ongoing, it has been partly reconstructed through interviews and an analysis of design materials. Interview quotes were translated by the authors.

4.1 Grasping the project aim

Nick (pseudonym) is an architect with ten years of experience. He started working in the firm a few months before the study. He was responsible for the design of a town hall (transformation and extension) for a small, rural municipality in Belgium, which had been granted through a competition before he joined the firm. Nick recalled that he was briefed on the project's concept orally by the firm's partner and further browsed the existing documents like the competition entry on his own.

Due to the lack of a clear design brief, Nick found it hard to grasp the project's requirements. The project documentation included a 40-page concept note, drawn up by the client, stating the project's aim and reporting on internal and external surveys and group discussions concerning the services of the new town hall. The researcher noticed that the most specific aspects, relating to measures, atmospheres and particular use scenarios, had been marked by the architect who worked on the project during the competition stage. However, the information was not complete. The concept note proved of little use to Nick. It did not give him any insight into how staff specifically worked and wanted to work, he commented.

Moreover, as a consequence of not having been involved during the competition phase, building on the design concept without having access to the thoughts of the previous architect (who left the firm) was not straightforward, Nick explained in the interview. An abstract concept such as "openness", which had been requested by the client and central to the competition entry, proved difficult to elaborate. Attempts to translate this into more concrete concepts such as transparency and landscape offices did not match the way the staff wanted to work.

4.2 Collecting first-hand information

Nick had therefore organised a small-scale field study to obtain a better understanding of the project requirements, he told in the interview. He had visited the existing town hall and spent one day observing and questioning the people working there. According to Nick, conducting fieldwork is rather unusual for architects to do.[1] Although minimising the validity of his study, because of his unfamiliarity with the "rules" concerning user studies, he highly valued the insights gained:

[1] Nick explained that the architecture firm in which he used to work conducted surveys amongst teachers for the design of a school, yet that this is not common practice amongst architects. He conducted the fieldwork on his own initiative and before the researcher joined the architecture firm.

> "Well, it's of course, when you go around to people to ask [some questions], some start telling their life story . . . so then you're thinking *oops (laughs)*. Well, no, I don't mind, but you don't get directly the input you were looking for. But on the other hand it gives you more insight into how people work. And apart from the fact [that they tell their life story], you actually also see the environment in which they work. So even if they tell you their life story, which doesn't relate directly to architecture, you do see how they work. I think it's enriching to see that. Because otherwise, I think the most dangerous thing as an architect, what many architects do and what is inevitable I think, is that you start from assumptions. You assume a lot. You think "that's a good idea", but sometimes in reality it doesn't work. Therefore it's good to have some kind of information from the client themselves, [about] how they are organised and work right now. . . . There should be a certain openness to look at things and to have a bit of a sense of reality actually. Because otherwise, you can come up with the most fantastic concepts or ideas, but if it doesn't work out for that specific client or target audience, then it's not really okay." (Nick)

This testimony illustrates Nick's genuine interest in, and respect for, users. Apart from gaining insight into the staff's everyday activities, the interaction also allowed him to add some hierarchy to the requirements, and even verify reactions to potential design solutions.

Yet at the same time, the full potential of his user study was not exploited. Although Nick indicated that he was interested in spatial information, the study was reported in a table that lists the requirements for every department (Figure 1). Observations and document analysis suggest that the medium of a table was chosen because it fit in with the textual type of reports that were used in official communication between architects and clients. It did not seem to fit architects' designerly ways of working. Nick admitted that it was even not communicated within the design team.

2nd floor	Occupation	Office material	Way of working	Remarks
Environment Department	2 Full-timers	1 big desk 1 wall with medium-high cabinets 1 wall with high cabinets Enough cabinets Chilly space during winter, also little daylight	Receive less citizens, received at the desks No need for a reception In the future maybe an increase in citizen contacts when the DifTar system will be established in the recycling park (SME's will need to pick up a badge)	Staff will be integrated in the Town and Country Planning Department

Figure 1 This table extract (concerning the municipality's Environment Department) illustrates how Nick reported on his field study in the current town hall (translated by the authors).

4.3 Fixating requirements

The form of the table might be partly accountable for the reduction of the rich information from Nick's field study into a fixation on measures in his following design process. For example, in his aim to live up to what he understood to be the client's wishes, Nick tried to fixate the number of linear meters of cabinets required for each department, and provide this in his design. What followed was a meticulous process of puzzling the specific requirements into a design proposal. During the days before an important meeting with the client, the researcher observed how Nick made several phone calls to client representatives to check how he could adjust other requirements as to fit in all the cabinets asked for. In the car to the meeting with the client representatives, the partner involved in the design project asked Nick to quickly calculate the number of cabinets in their design proposal one last time. Nick was messing about with the documents in the passenger seat for a while, until fortunately the calculator indicated that the requirements were met.

In the meeting, which the researcher also attended, however, the client representatives commented that certain departments had too many cabinets. The architects were disappointed that the requirements they had held on to turned out to be not that important. They seemed unamused with yet another change of requirements. The importance attached to fixed requirements relates to architects' ways of working. As designing is such a complex activity, architects first need to set the boundaries of the space in and in relation to which they can develop solutions. As Nick explained:

> "it's a support that is practical because you have a kind of starting point. . . . So, that part of organisation and square meters, that's something that has to be done, I think. And after that . . . you start with the atmosphere or architecture. But first the preconditions should be right." (Nick)

4.4 Puzzling (together) with users

An alternative way of representing user requirements that is more in line with architects' skills was observed in Nick's design materials. In an early design stage, Nick was drawing schematic floor plans (Figure 2), with abstract building blocks that represented programme units and that could be configured into the building's layout like a puzzle. This translation is visual and dynamic, which made it suitable in the reflective practice of designing. As Nick explained, "you can say 'we remove one office' and then you strike it out with a marker, so to speak".

The schematic floor plans also proved a useful tool in meetings with the client representatives. In the interview, Nick stressed the importance of having concrete material to talk about. The (schematic) floor plans, but also physical or virtual models and renderings become the objects of discussion. As those objects display potential design solutions, they provoke immediate and concrete feedback. Moreover, when they can be manipulated, clients are drawn into the reflective design process, proposing, discussing and evaluating different alternatives together with the architects. In the meeting with the client representatives, it was observed, e.g., how the schematic floor plans were used to re-negotiate the capacity (e.g., the number of meeting rooms) and room typology (e.g., landscape office) in terms of spatial efficiency.

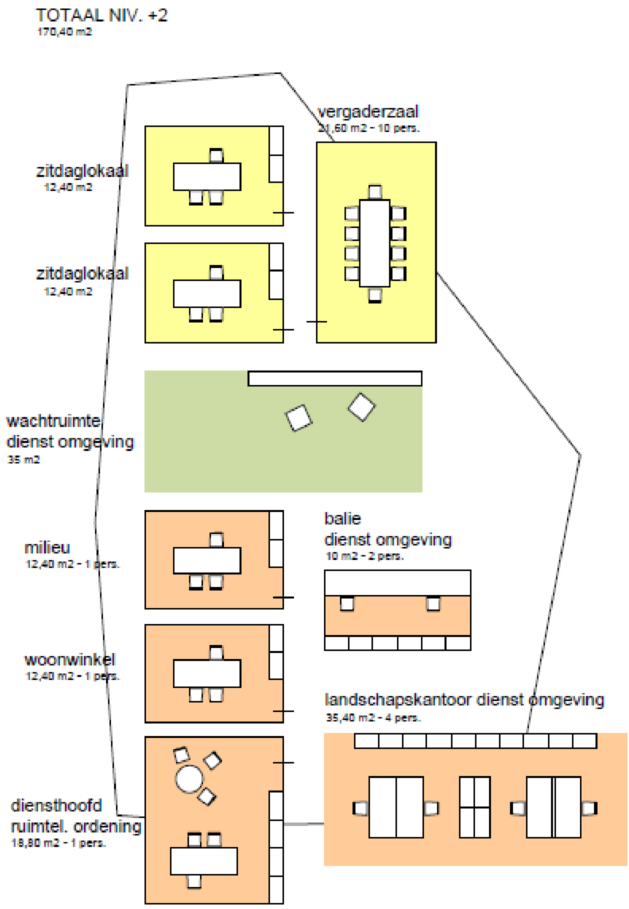

Figure 2 This schematic floor plan with programme units (representing the second floor of the town hall's new extension), which Nick made to develop the building's programme and design, proved a useful tool in meetings with the client representatives.

5. Insight into designerly ways of knowing

The fieldwork account of Nick's quest to understand users' needs in the design of a new town hall provides insight into the social and material aspects of architects' designerly ways of knowing about users.

We first observed how acquiring knowledge about users through a traditional design brief was ineffective, and how Nick alternatively collected first-hand information from users himself through a small-scale field study in the current town hall. His appreciation of the contextualised information about how people's jobs are organised in relation to their environment gives us insight into the information content that is relevant to architectural design practice. Yet, internal communication problems hampered the knowledge flow in the architecture firm. For instance, knowledge acquired during the competition stage stayed with the architect who left the firm and one of the partners, knowledge generated through the small-scale field study stayed with Nick. Our observations suggest that these problems result from a lack of organised knowledge sharing in the firm (a social aspect) combined with a lack of adequate ways to represent this knowledge (a material aspect).

We also observed how the knowledge generated through Nick's small-scale field study was transformed into requirements that largely relate to spatial dimensions (e.g., linear and square meters of cabinets and office spaces) and relations (e.g., whether office spaces should be open to the public, or shared with colleagues). Nick generated further knowledge about the implications of design decisions by iteratively testing different options in sketches and schemes. This understanding through design materials is an essential activity in architects' design process (cf. Schön 1983). It also has a social aspect, as we observed how the partner of the firm interacted with Nick through these design materials as well, the building design was collaboratively negotiated.

Yet, we finally observed how requirements had to be re-negotiated in a meeting with the client, as architects' transformation of what they understood to be users' needs into concrete design features did not correspond to the wishes of the client representatives. Here again, the material representation of users' needs into easy-to-manipulate schematic floor plans played an important role. As non-designers, client often have difficulties with reading floor plans. The recognisable and unfixed programme units allowed them to collaboratively explore spatial relationships between the programme units and further develop the building's programme. This "client learning" (Siva and London 2011) might account for their disagreement with architects' proposal and seemingly change of early requirements.

Our findings indicate that informing architects includes more than just providing static information through reports. It is also a dynamic process that involves design materials and interactive relationships with stakeholders. We refer once again to the schematic floor plans to illustrate materials' ability to mediate attention for users in a designerly and even collaborative way (cf. Ewenstein and Whyte 2009; Luck 2007).

Judging from this fieldwork account, information formats based on architects' own design skills and materials may hold the potential to communicate and further investigate specific user needs in an interactive and design-oriented way. This is difficult with the reports or lists of requirements that are typically used in architectural practice, as observed in the fieldwork. We identified potential, however, in architects' creative skills to imagine and represent spatial experience. Making users' experiences explicit in design materials enables negotiation (e.g., with clients), which can enhance attention to user needs.

Our call to mobilise architects' design expertise (e.g., their representational skills, cf. Kasalı and Nersessian 2015) challenges architects' as well as researchers' role in knowledge transfer. The advantage of an ethnographic research approach is that it provides a way to map the socio-material mediators of knowledge about users. These are the preconditions of architectural design practice with which novel information formats should tie in.

6. Reflection on the research approach

6.1 Possibilities

In ethnographic fieldwork, the researcher's identity plays an important role. The first author's profile turned out to be appropriate. Whereas her studies in architectural engineering provided a shared background, enabling her to understand the language of this culture of practice, her lack of professional experience seemed to invite participants to explain the particularities of architectural practice, as if she were an intern that had to be instructed. Also non-professional aspects (e.g., a shared music taste) allowed her to develop a relationship. Particularly the joined lunches provided access into the community. Overall, the researcher was able to build up rapport.

The pilot study also provided an opportunity to develop observational techniques. During discussions amongst participants, the researcher paid attention not to be intrusive. Plunging into design documentation proved useful at these moments. Only during in-depth interviews, she played out her role as a researcher, including visible note-taking and audio recording. The personal focus on interviewees made them feel that their opinions were valued. Moreover, because the interviews took place behind closed doors, they had an air of mystery, making some participants curious and willing to participate. The interviews provided the researcher a moment to step back and take some distance from the field. Also participants appreciated the opportunity to reflect upon their way of working. As one of them remarked, "*(astonished)* It's actually the first time I think about this. I think it's interesting, yes, I do". In her ethnography of the Office for Metropolitan Architecture (OMA), Yaneva (2009, pp.30–35) similarly describes the benefits of observing "at two different distances".

The ethnographic fieldwork techniques proved valuable to study how knowledge about users is generated, shared, transformed and represented in the design process. Only by assembling the data from different techniques, the meaning of the situation could be more fully grasped. For example:

- according to architects' statements in the interviews, not all documentation provided proved useful in the design process (e.g., the 40-page concept note), which could not be concluded from analysing the design materials alone;
- on the other hand, architects themselves seemed not to be fully aware of the potential of their designerly ways of representing and working with user needs, as observed by the researcher (e.g., the easy-to-manipulate schematic floor plans).

This interpretation based on assembling data from different sources is key to ethnographic research. The role of (design) materials was certainly more than being the tangible evidence of architects' design process. Materials also served as probes to elicit more explanations or narratives by participants, making them crucial to the research methodology.

6.2 Limitations

Although the researcher's background made it easier for her to understand architects' language, we should remark that it was not always easy to grasp the meaning of design materials without explanation. This was also mentioned by a participant in the fieldwork account above. The difficulty does not relate to understanding conventions, but to certain materials' role of design medium rather than communication means. However, the aim was not to conduct an isolated document analysis, but to assemble different sources. In this respect, the design materials also served as occasion to ask participants for explanation, as mentioned.

The main limitations of the fieldwork relate to timing. The researcher had planned a part-time presence in the architecture firm, to allow simultaneous data collection and processing and adjusting both. However, being present at a particular meeting proved challenging, as architects' planning tended to change constantly. Moreover, a part-time presence made it difficult to participate in design activities. The researcher could only perform ad-hoc tasks (e.g., assisting in making a scale model) not requiring a full-time presence. Her timing was never synchronised to that of the firm – an issue also Yaneva (2009, p.35) experienced.

Timing is a challenge that deserves further attention in future studies. When the researcher finally managed to attend an external meeting with client representatives, this meeting provided extremely interesting data. Indeed, the starting points of the approach signal the importance of architects' social environment. Therefore, in future studies, more attention will be paid to expanding the research field beyond the architecture firm, as to include clients' and other stakeholders' perspectives.

7. Conclusion

This paper confirms design researchers' assertion that an ethnographic research approach allows for an in-depth understanding of architectural design practice. The fieldwork account gives outsiders a feel of the kind of issues architects need to handle in daily practice. Moreover, it shows the added value of a research approach that takes into account the socio-material environment (which is reflected in the findings), instead of just focusing on information characteristics isolated from the practice in which it is used.

Findings indicate that informing architects about users' experiences includes more than just providing static information (e.g., through reports). It is also a dynamic process that involves design materials and interactive relationship (e.g., in a design team, between architects and clients). An ethnographic research approach provides a way to map the socio-material mediators of knowledge about users. These mediating aspects that characterise architects' design practice are key in addressing the challenge of transferring knowledge about users' experiences into architectural design practice.

Insight into how knowledge about users is embedded in architects' ways of working is expected to inform the development of new, tailored formats for informing architects about users' experiences. Mobilising architects' creative skills is identified an opportunity for more effective knowledge transfer. This challenges architects' as well as researchers' role in transferring knowledge about users' experiences from research into practice.

In our future research we will conduct more studies, in a variety of architecture firms (working on diverse projects), in order to acquire a better understanding of their (different) designerly ways of knowing about users. Combining this with an analysis of the potential of information formats from other design disciplines, is expected to inform the development of design-oriented formats to foster insight, empathy and innovation in architectural design.

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SECTION 21

INCLUSIVE DESIGN

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DRS2016
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Future-Focused Thinking

2016 Design Research Society
50th Anniversary Conference
27-30 June 2016, Brighton, UK

Introduction: Inclusive Design

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DOI: 10.21606/drs.2016.610

The Inclusive Design Research Special Interest Group (Inclusive SIG) of the Design Research Society provides an international platform for researchers, design practitioners, and the general public to exchange knowledge about accessible and attractive design and to empower wider participation in the design process.

The main foci of the Inclusive SIG include:

- Building and advancing knowledge for inclusive design and research
- Creating and evaluating tools and methods for inclusive design practice
- Developing strategies for engaging designers and the public
- Exploring new territories of inclusive design for the majority world
- Through these activities, we aim:
- To share best practice in contemporary design, research, education, and public engagement
- To keep pushing the boundaries of inclusive design and explore its potential in different contexts

As one of the special interest groups of the Design Research Society (DRS), Inclusive SIG organizes symposia on a regular basis, and the inclusive design session for the 2016 DRS received 18 papers, in addition to the relevant submissions from the open call. Following a thorough review process and strict selection criteria, 11 papers were selected for presentation at the conference. These papers cover a diverse range of topics, from redefining ageing, measuring user capabilities, to assessing product-related stigma.

For example, the paper ‘Designing for older people: But who is an older person?’ by Raghavendra et al. from University of Canberra, Australia， addresses one of the critical aspects of inclusive design discourses, i.e. the definition of ageing. It reports the experiment investigating if redundancy in interface design can facilitate intuitive use in older users and users with low technological prior experience. The findings proved that diversity in older age groups presents a great challenge in developing intuitively usable interfaces. The research suggests that looking at a target group based on their cognitive abilities instead of chronological age will provide an much more effective approach in dealing with this challenge.

Understanding user capability has been a topic for inclusive design for many years; the main challenges include: lack of appropriate definition of product-design related capabilities or related measurement scales and methods. The paper 'Towards designing inclusion: insights from a user data collection study in China' by Ning and Dong from Tongji University, has attempted to collect user data of 130 older persons in China, covering many areas of competence, from the more quantitative domain of biomechanics, interaction, to more subjective and qualitative areas (e.g. comfort). As a pilot study in collecting Chinese older people's capabilities in relation to product use, the study explores the relation between 'maximum' and 'comfortable' capability measurements, and verifies the feasibility of establishing predictive models of successful product interactions in the 50-70 user group. This study has provided promising directions for further exploration of user data.

With increasing longevity and changes in population demographics; designers, engineers and architects are faced with the challenge of providing older adults with enabling technologies and home environments that facilitate physical activity and wellbeing. For instance, there is an overall theme that older people encounter difficulty in opening household packaging for a variety of reasons. Ma and Dong's paper reports upon a survey-based investigation into such difficulties encountered by older Chinese individuals. The paper not only identifies difficult packaging types from the older users' perspectives, but also tackles the problem by considering several critical design research areas such as user participation in the design process, end user acceptance, decision-making and inclusion.

Lim and Nevay from the University of Dundee also focuses on the design process. Their paper reports a co-design project, involving care-home residents, to address the issue of acceptance and adoption of wearable technologies for older adults to monitor their activities and movements. It describes a 'craft-based' approach 'to allow designers to understand and uncover people's capabilities and needs in a non-intrusive and empathic way'. The paper raises, at the outset, the issue of non-compliance of current wearable technologies, and posits that co-design of these with older adults - through a 'crafting' process - will provide a greater sense of ownership and acceptability of designs. The authors' particular emphasis is on the 'crafting' of these artefacts, suggesting this is being led by 'non-techies' which may prove of significance in the design of acceptable technologies.

Dijk and Verhoeven's paper 'to shed some light on empowerment: towards designing for embodied functionality' uses a participatory design project to examine whether an interactive lighting system could empower a person with autism by supporting domestic activities. Reflecting on the case the authors develop the vision of *Embodied Functionality* (EF) and argue that designing for EF goes beyond 'distributing' information technology in the environment and opens up an alternative design space, holding the promise of a more successful appropriation of interactive (assistive) products into people's everyday lives.

Stigma is a subject frequently discussed within the field of inclusive design, however measurement of this trait is under-explored. The paper 'Product stigmaticity: measuring product-related stigma' (by Kristof Romain Viktor Vaes, Pieter Jan Stappers, Achiel Standaert) presents two measuring techniques that aim to objectively assess the 'degree' of 'product-related stigma' (PRS) that is 'attached' to products. It is argued that both experimental techniques are predominantly suited as comparison tools, able to compare products on their PRS-eliciting potential. It is expected that designers and developers to use these results to justify design decisions with quantitative data, to assess which product properties have influenced certain reactions, and to what extent subsequent improvements have been successful.

The selected papers not only address the traditional dimensions of inclusive design, i.e. young-old, able-disable, professional-lay, but also raise emerging topics such as participatory action and the cultural aspect of inclusive design.

Through case study analysis, Nicola St John's paper 'Towards more culturally inclusive communication design practices: exploring creative participation between non-Indigenous and Indigenous people in Australia' explores and discusses a more culturally inclusive communication design practice particularly in relation to framing a process for creative participation and creation between Non-Indigenous and Indigenous people within Australia. It draws from and applies principles of Transformative Participatory Action research to communication design practice. This approach moves away from co-design and participatory design models to focus more on participatory action, active engagement and empowering Indigenous communities through design.

Zhao Chao, Popovic Vesna and Lu Xiaobo's paper 'Designing meaningful vehicles for older users: culture, technology, and experience' investigates Chinese middle-aged vehicle users and older vehicle users pertinent to their current travel experience and future travel needs. The study utilizes grounded theory to analyze the travel activities of two age cohorts and compare the travel-needs-influencing factors. The researchers have adapted technique of interviews, logbook and co-discovery to help collect data and explore these factors within the Chinese cultural frameworks. The study contributes to a framework and method for automotive designers to incorporate user feedback in a human-centered design process, aiming at designing vehicles that are both meaningful, functional and locally relevant for an aging population in China.

Grangaard's paper 'Towards an innovative and inclusive architecture' describes a study investigating how architectural firms and organizations related to disability in the built environment perceive and work with the Danish Building Regulations Accessibility Requirements. It discusses about accessibility regulations, in particular the challenges they present by forcing the firms to consistently meet the prescribed requirements as opposed to the behavioural/experiential needs of the users, when not all users have the same accessibility needs.

David Fassi, Laura Galluzzo and Liat Rogel report a series of design interventions that open up the Bovisa Campus of the Politecnico di Milano as a hidden space to its surrounding communities, aiming at making normally hidden marginalized public spaces within a university campus accessible to the wider community. The paper presents a means of engaging students in future thinking and how design and design education might play a more active role in enabling such practices to be more systematically developed through a series of social activities, highlighting how design research as a creative and active force invites reconsideration of ideas about design and its role in shaping our lives in more expansive ways.

With these interesting papers addressing inclusivity from a variety of perspectives, I expect that the Inclusive Design session to provide an inspirational form for discussion and debate. For example, although engaging users creatively in the design process could help increase the sense of ownership of the participants, thus increasing the acceptance of the final design, with designers being knowledge users of inclusive design knowledge, there is a challenge yet to be addressed, i.e. how such user data would be made available, accessible and attractive to designer practitioners to exploit. We hope participants will share experience and good practice and help move the filed forward.

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Designing for older people: But who is an older person?

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Abstract: This paper explores a critical aspect of designing for older people. It argues that we need a clear description of who is "an older person". Or, when a person starts being old from middle age. Research has well established that there is greater variability in abilities among older than among younger people. This often creates problems in designing intuitive product interfaces for this target group. Intuitive design is basically about developing interfaces that reflect target users' familiarity. However, when the target group are very diverse in their capabilities and familiarity it makes is extremely difficult to design intuitive interfaces.

Our research suggests that the main reason for this predicament is due to excessive focus on chronological ageing. And, if we look at a target group based more on their cognitive abilities instead- it will provide us much more effective approach in dealing with this problem.

Keywords: intuitive design; older people; cognitive ageing; inclusive design

1. Introduction

The intuitive use of an interface involves subconscious use of users' prior knowledge. Thus, design for intuitive use basically involves two steps: 1) to understand domain-specific prior experience of the user; and 2) to design interfaces that reflect this prior experience. In reality, however, research shows that it is much more complex to implement this framework (Blackler, 2008; Hurtienne, Weber, & Blessing, 2008). To start with, investigating what target users are familiar with is a very resource intensive process, both in terms of time and money (Spool, 2005). In addition, no two users share similar prior knowledge. Especially so if the target group is older people, who are lot more diverse both in terms of their prior knowledge and capabilities.

This paper will discuss a way to address this issue based on a study that investigated redundancy as one of the strategies that could bridge the variability in older people's capabilities, and help them use complex technological devices intuitively. This study was specifically designed to investigate age differences from the perspectives of both chronological age and cognitive abilities.

2. Diversity

There are many reasons behind older people being deficient in prior knowledge and more varied in their capabilities. For example, age-related cognitive degradation (Langdon, Lewis, & Clarkson, 2007; Lim, 2009), low perceived self-efficacy (Bandura, Freeman, & Lightsey, 1999; Czaja & Lee, 2007) and cohort effects (Docampo Rama, Ridder, & Bouma, 2001; Lim, 2009).

As people age, they tend to specialise in an area of their choice. Their other interests also tend to become more focused. Each individual has different needs, professions and interests, and this brings about the variability in older people (Salthouse, 2010) . Older people are also slow in adopting new technologies, as they do not see a need to keep up with technology for the sake of doing so. However, where they see a need, they do embrace the technology without reservations (Czaja & Lee, 2007). Finally, age-related cognitive decline slows down acquisition of new knowledge (Bäckman, Small, & Wahlin, 2001). The awareness of this limitation probably also compels older people to be more selective in determining what they should learn.

These and other related factors results in two issues regarding domain-specific prior knowledge in older people: 1) the variability in their knowledge and 2) knowledge that is not in pace with contemporary technology.

3. Ageing and cognitive processing

The process of ageing leads to decline in cognitive skills, which in turn affects learning of new information. Some research points out that this decline is not global or linear, as not all skills are affected with ageing (Bäckman et al., 2001). There is ample evidence that age-related memory impairment varies greatly between individuals. Memory is broadly categorised into two systems: 1. Short-term or Working Memory and, 2. Long-term Memory. Of these two, Working Memory is most affected by age-related degradation.

Working Memory is not a unitary system. Baddeley and Hitch (1974) proposed a multiple component system that emphasised functional importance rather than just storage. This system comprises of three components (later expanded to four), the Phonological loop, the Visuospatial sketchpad, the Central Executive and the most recent addition the Episodic buffer (Baddeley, 2002). The Central Executive is engaged in reasoning, decision-making and co-ordinating the activities of other subsidiary systems. In general, Working Memory function deteriorates with ageing. Moreover, age-related Working Memory deficiencies becomes more prominent as the complexity of cognitive tasks increases, such as when a task requires simultaneous storage and processing of information (Bäckman et al., 2001). Salthouse and Babcock (1991) found that ageing related decline in Working Memory is mostly due to slowing down of the Central Executive component. However, manifestation of Working Memory deficiencies in ageing is often mediated by coping mechanisms adopted by older individuals (Brébion, Smith, & Ehrlich, 1997).

3.1. Attention and ageing

A variety of behavioral inefficiencies are attributed to age-related changes in attention. In general, attentional capacity is conceptualised as limited supply of energy that supports cognitive processing. The Central Executive is thought to play a key role in directing and controlling attention (Baddeley, 2002; Norman & Shallice, 2000). Attention is a term used to describe a variety of cognitive functions. It is usually defined in literature by its various functions. For example, “Selective-attention” is processing of one source of information at the expense of other, “Divided-attention” is simultaneous processing of two or more sources of information, “Switching-attention” is alternatively processing one source then other, and “Sustained-attention” is maintaining a consistent focus on one source (McDowd & Shaw, 2000). However, this is a framework used to organise and present information in reporting literature on attention. In reality, complex tasks require more than one attentional function for cognitive processing.

Age-related decline is most noticeable in Selective-attention and Divided-attention functions. Selective-attention, the ability to attend selectively to relevant information and ignore irrelevant information, is considered a prerequisite for extracting relevant information from distracting or irrelevant detail (Kramer & Madden, 2008; McDowd & Shaw, 2000). Some researchers argue that age-related decline in selective-attention is due to the inability of older people to inhibit task irrelevant information (Hasher & Zacks, 1988; Morrison, 2005).

4. Experiment design

This experiment was designed to investigate if redundancy in interface design facilitates intuitive use in older users and users with low technological prior experience. Redundancy refers to a repetition of content in different format. The repetition has to be in an alternative physical form, for example, voice and text or picture and text (Wickens, Lee, Liu, & Becker, 2004). This experiment used a cross-sectional, between-groups matched-subject design. Participants for this experiment were recruited from various organisations (like, sports clubs, educational institutes, recreational facilities and retirement resorts). Overall 50 participants between ages 18 to 83 participated in this study.

4.1. Apparatus and measures

This experiment used a virtual version of commercially available body fat analyser (*Figure 1*) for the trials. This research utilised multiple data collection methods. These were verbal protocol, observation of task performance, interviews and rating scale questionnaire and cognitive measures tasks.

Figure 1: Virtual body fat analyser device with modified interface and controls to represent Redundant interface

Technology prior-experience was captured using a two part questionnaire. Cognitive abilities of the users were captured using CogLab. CogLab is a cognitive measures software (Blackler, Mahar, & Popovic, 2010) that administers various instruments that measure different aspects of cognitive function. For this experiment following instruments were used.

Corsi-span and Digit-span: Measure of visual sketchpad and phonological loop capacity. A standard Corsi Span task was used where participants viewed sets of squares on the screen that recalled their location by button click. The number of squares presented was varied using a staircase procedure to find the participants visual span. Similarly, Digit Span was measured by presenting lists of digits one at a time on the screen. Participants recalled the lists by clicking on a number pad on the screen. Again a staircase procedure was used to very the list length.

Visual and Phonological transform task: Measure of Central Executive capacity to manipulate spatial and phonological information. In the Phonological transform task participants viewed a set of 4 numbers then were required to move each number forward by 4 places (e.g. 5 would become 9). Similarly, in Visual transform task participants viewed a pattern of 4 dots on a disk then were required to rotate them 4 places in clockwise direction.

Go/No-Go task: Sustained attention and response inhibition. This instrument was also used to measure Choice Reaction Time of participants. In Go/No-go (Nielson, Langenecker, & Garavan, 2002) task participants viewed individual alphabets serially on the screen and are required to respond to stipulated targets. There are 3 sets of trials in this task. First set: they are required to respond, by clicking a button, when ever they see specific alphabets (X,Y and

Z), second set: they are required to respond to only alternating target letters (X, Y, X, Y) and in the third set: participants are required to respond to three alternating target letters (X, Y, X, Z, Y, Z).

The data from Noldus Observer, Technology prior-experience questionnaires and Cognitive Measures software were exported into SPSS for statistical analysis.

5. Summary of findings

The outcomes of this study have highlighted that older age groups, when compared with younger age groups, are very diverse in their capabilities in terms of technology prior experience and cognitive functioning. As can be seen in Figure 2 shows the variability in *time to complete the task* increases with *age*, with the younger group being more homogeneous than the older age group.

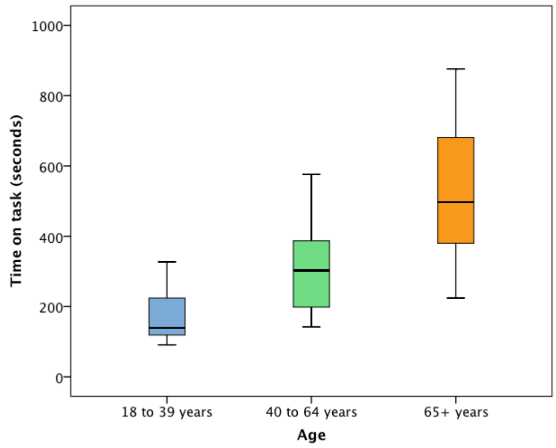

Figure 2: : Box plots for time on task by three age groups

Most importantly, contrary to what was hypothesised, older participants (65+) were significantly faster on the text-based interface when compared to the redundant and symbols-only interfaces. We were expecting a redundant interface to be more beneficial for older people. However, the text based interface turned out to be much more intuitive, faster and less prone to errors for older users and users with low domain-specific prior experience. Most importantly, there were no differences between young and older age groups in terms of errors on a text-based interface.

This finding has shifted our focus to cognitive data to understand the underlying reason for these unexpected results. One of the reasons that emerged was that this could be due to age related degradation in visual information processing, as both symbols-based and redundant interfaces are visually more complex to process compared to text-based interface. In addition, it also provided us insight into how we could address the diversity in older age groups.

6. Chronological age versus cognitive age

Once we examine cognitive abilities against chronological age it gives a clear indication that age related cognitive decline is not liner nor consistent. For example, sustained attention is a good indicator for cognitive ageing/capability of a person. And as can be seen in Figure 3 it does not decline linearly with age. The higher number on sustained attention is an indicator for normal functioning. The question this raises is “at what range of cognitive ability a person is considered young, middle and old?” The scatter plot clearly shows the irrelevance of chorological age as an indicator of capability.

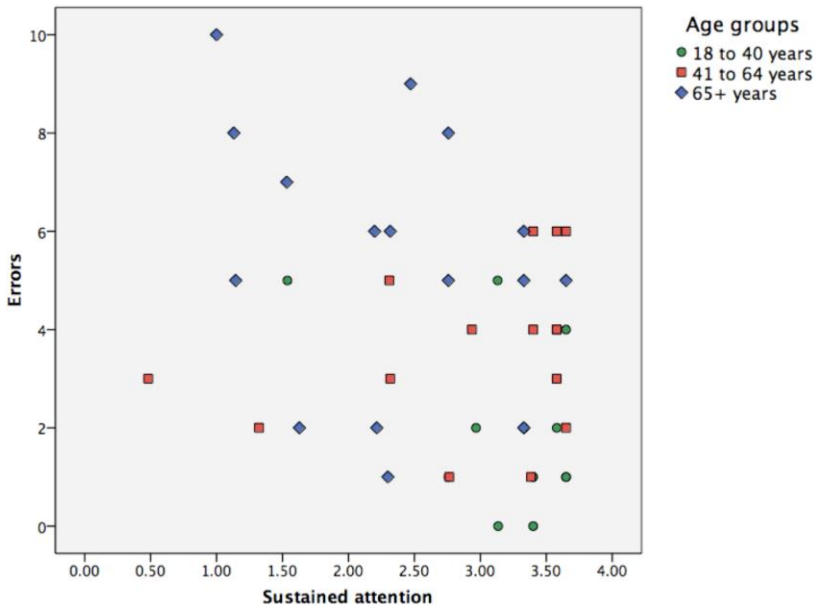

Figure 3: Sustained attention errors

The scatter plot for different functions of central executive plotted against age shows similar trends. As can be seen in Figure 4 , visuospatial sketchpad capacity (Corsispan) declines with age in a linear fashion but it is not universal. Phonological transform response time (PhonologicaltranformRT) increase with age, and its variability also increases as age progresses. On the other hand, sustained attention (pgng2d) decline is a little more varied. Both transformation response time and attention are functions of central executive. This shows that age-related cognitive decline is not linear, and it not only varies from person to person but also between different cognitive functions.

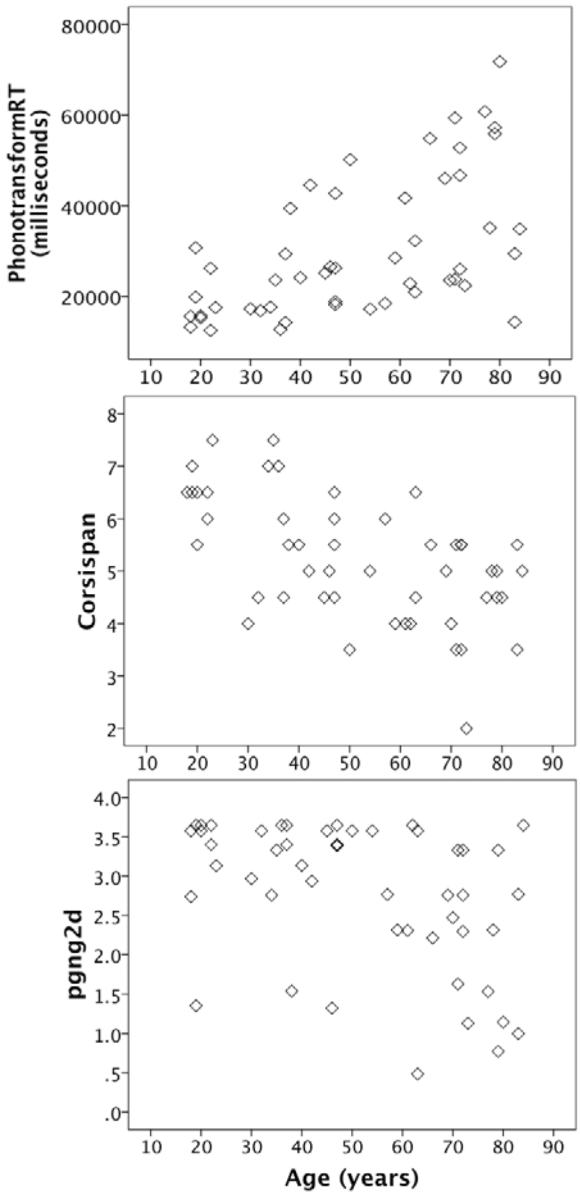

Figure 4: Performance on cognitive tasks and chronological age

The advantage of this data is that it provides us an insight into behaviour of a user on an interface. For example, visuospatial sketchpad capacity correlates with use of visually intensive interfaced design. Sustained attention correlates with errors and ability to recover from errors.

Age, technology prior experience and cognitive ability

Interestingly, we also realised why prior knowledge alone is not a good indicator of users' capabilities. The core of any "user centric design" or "design for intuitive use" process is to match a user's prior knowledge to functions and features of an interface design. However, it should be noted that cognitive ability plays a mediator role in the relationship between age, technology prior experience and performance on various tasks. For example, scatter plots

(Figure 5) of time *on task*, technology prior experience (TP), *age* and *sustained attention* from the Experiment 1 data clearly show that, although some cases scored high on the TP (for example, case 37 in the plots; red arrow), they took more time on the task. However, as can be seen in the second plot, their score for sustained attention is low. In some cases, it is the reverse (for example, case 2 in the plots; green arrow); they scored low on TP, high on sustained attention and took less time on task. This data suggests that cognitive ability is a mediating variable for *the time on task* and *prior experience* relationship.

Cognitive capability, especially central executive function, plays a crucial role not only in the retrieval and processing of information from long-term memory, but also in acquiring this information (Langdon, Lewis, & Clarkson, 2010; Lim, 2009). In short, both cognitive abilities and domain-specific prior knowledge are essential for successful use of product interfaces. Cognitive ability influences retrieval and application of relevant knowledge. It is also essential for efficiently learning unfamiliar features in the interface.

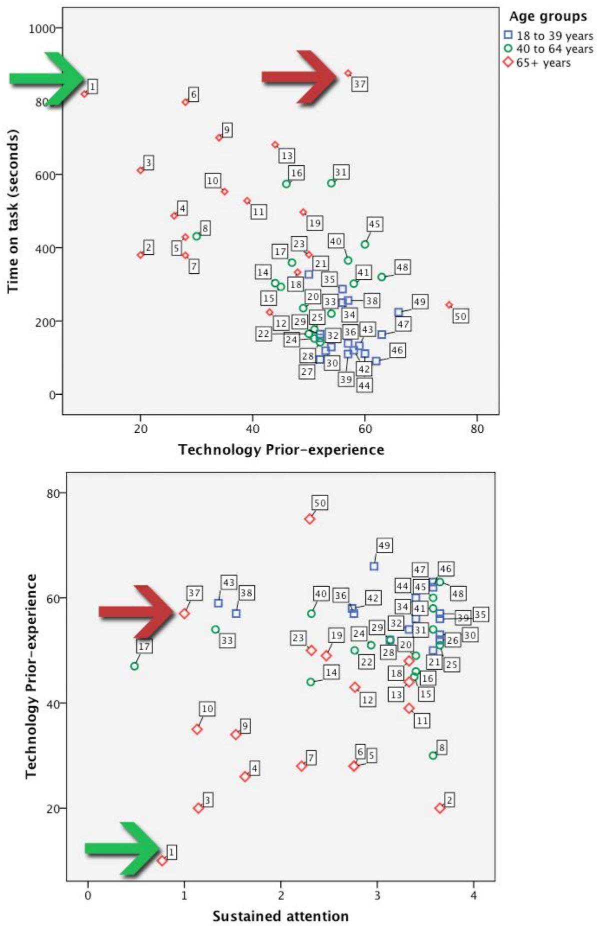

Figure 5: Scatter plots showing how sustained attention mediates the relationship between technology prior experience, age and time to complete the task

7. Discussion

The dictionary definition of "old age" is "the later part of normal life". What is normal life? 60+ years as old age is based on retirement age that was set when life expectancy was lower than currently. There is no conclusive evidence that shows that a person becomes old at 60 or 65 years. This not only perpetuates stereotype of "old" but also clouds objective research.

We realised during this study that if we look at our target group based on their capability (cognitive, sensorimotor) it is lot easier to address their problems. However, one of the problems with the proposed approach is that there is no standardised way to measure capability of a user. There are many validated instruments for measuring cognitive functioning of a person but their measurement scales are different. This makes it difficult to compare data from two independent studies that use different measurement instruments. Ideally, we want a set of easy to use universal instruments where we can get data that can be compared with similar studies elsewhere.

8. Conclusion

Diversity in older age groups often presents a challenge in developing intuitively usable interfaces. One of the ways we can address this problem is by shifting our focus from chronological age to cognitive capabilities of a user. We argue that chronological age is an arbitrary number that does not provide a stable ground for objective research. However, if we group our target users based on their capabilities it will provide us with a more effective approach in developing a solution.

In terms of capabilities, apart from sensory-motor functions, cognitive abilities provide a clear picture of a person's capability. Overall, our study strongly suggests that research on ageing and use of technology should focus less on the age variable and more on the source of age-related differences. Although chronological age is useful for understanding patterns of technology usage, preferences, and difficulty, it does not explain why these differences occur. To determine this; there is a need to investigate mediating variables such as cognitive abilities and domain-specific prior experience. In short, we should design based on capabilities of a target group rather than chronological "age".

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Towards designing inclusion: insights from a user data collection study in China

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Abstract: User data has been identified as one of the important knowledge bases for inclusive design. In order to explore the influential factors that may affect the reliability of data and then build up a more effective and efficient data-collection framework, we carried out an experimental study to collect data from older people (aged 50~70) in China, which included users' capability, psychological and social-cultural attributes. Users' actual product interaction performance was also investigated. Three issues were discussed based on the outcome of data analyses: a) mood states have significant effects on respondent's self-reporting results; b) compared with maximum settings, people may have a wider range of perceptions of "comfortable" settings and it is possible to predict the performance in a "comfortable " setting based on "maximum" data; c) social-cultural variables, vision, hearing, dexterity, cognition and psychological characteristics can predict successful product interaction tasks at different levels by using multiple logistic regression analysis.

Keywords: inclusive design; user data; capability

1. Introduction

Inclusive design focuses on making mainstream products and services usable by as many people as is reasonably possible, without requiring them to use specialized adaptations (Keates and Clarkson 2004). Dong et al. (2015) identified the important knowledge bases of inclusive design: a) theoretical models, b) user data, c) best practice exemplars, d) methods and tools and e) policy, standards and guidelines. Specifically, to address the knowledge needs of knowledge users (e.g. designers, manufacturers, policy-makers, charities, etc.) became an important research orientation in the practice of inclusive design (Clarkson and Coleman 2015).

Designers are an important group of the knowledge users of inclusive design (Dong, et al 2015). In order to understand the diversity of the population and design for the widest possible range of users, including the elderly and disabled people, inclusive design data is regarded as one of the effective means to ensure better design inclusion (Tenneti, et al 2012). An inclusive design database is expected to be an integration of anthropometric, capability, psychological and social-cultural data, with designer as the end user. It requires knowledge about the capabilities, needs and aspirations of potential users, meanwhile, it must also take wider psychological, social, and economic considerations, which would help designers gain a more accurate understanding of users' interactions with products and technology (Langdon, et al 2015). Consequently, it raises the requirement for collecting inclusive design user data for designers to make products and services accessible to the widest range of users, irrespective of their impairment, age or capability.

Some key issues in the research and practice of collecting inclusive design data have been identified (Johnson, Clarkson and Huppert 2010; Langdon and Thimbleby 2010):

- Comparison between self-report and performances;
- Measurement granularity: activities, tasks and component functions;
- Potential influences (such as psychological resources and physical context).

We conducted a study to collect end-user data that aimed to identify specific issues listed above. The study was initially derived from the project *Towards Better Design* (2010) done by the University of Cambridge. After the first round of adaptation and pilot studies, suggestions and principles of implementing such a data collection survey in China were proposed (see Ning and Dong 2015; Ning and Dong 2014; Huang and Dong 2015). Based on the findings from the pilot studies, the second round data collection was carried out to clarify emerging issues from empirical studies, including detecting the influence of mood states, exploring the relations between "maximum" and "comfortable" measurements, and verifying the feasibility of establishing predictive models of successful product interactions in the 50-70 years old user group.

2. Methods

A face-to-face survey was adopted in this study. The target respondents were set from age 50 to 70, the user group we defined as the "young-old", as they are experiencing the evolvement of new technologies like the Internet and mobile technologies. The data collected in this study included:

- Capability data (vision, hearing, dexterity and cognition);
- Psychological features (mood states, general self-efficiency and technical self-confidence);
- Social-cultural information (employment, education, income, living conditions);
- Product interactions (opening packaging and mobile phone operating tasks).

The specific survey items and methods applied are summarized in Table 1.

Table 1 Review of the survey items and methods.

Items	Methods
General health condition	Self-assessment (general)
Vision	Self-assessment (general and scenario-based), Visual chart test (acuity and contrast)
Hearing	Self-assessment (general and scenario-based)
Dexterity	Self-assessment (general and scenario-based) Grip strength test Picking up objects test
Cognition	Self-assessment (general and scenario-based) Icon cognition test
Psychological features	Self-efficiency scale Technical self-efficiency scale Mood state (POMS scale)
Social-cultural information	Self-report
Product interactions	Packaging opening test Mobile phone task test

2.1 Capability data

Different means were adopted to capture users' capability data, for example, self-report and performance test. In order to investigate more practical information in a product-using context, scenario-based questions (e.g. "What's the frequency of your missing a phone call because of not being able to hear the ring?") were incorporated with general self-reporting questions of capability assessment (e.g. "How do you assess your hearing capability?").

It should be noted that the capabilities of "mobility" and "reach and stretch" were not included for the reason that significant ceiling effects were found both in terms of self-report and performance tests in the first pilot study carried out earlier (Ning and Dong 2015). But for the future large-scale survey involving a wider age range, it is necessary to investigate these capabilities.

2.2 Psychological features

Mood state, general self-efficiency and technical self-confidence were applied to investigate the psychological features. In this study, we adopted a POMS (Profile of Mood State) scale to explore the effects of mood on respondents' reports and performance. The POMS scale is a checklist designed to measure the transient emotional states of tension-anxiety, depression-dejection, fatigue-inertia, vigor-activity, confusion-bewilderment and anger-hostility (McNair 1971). It has been proved as a reliable and valid measure of mood states in older adults (Gibson 1997). There are many adaptive versions of POMS scales that have been developed to fit different contexts. Due to time limits, we chose a short version that adapted from Grove and Prapavessis' work (1992).

A simplified version of self-efficiency scale was applied to measure self-efficiency. Self-efficiency describes an individual's perception of his or her capabilities to perform and complete a task. A person who has a high self-efficiency degree could be more active and confident in handling different issues (Bandura 1977).

Technical self-confidence is correlated with the performance of successful product interactions (Combe, Harrison and Dong 2013). In this study, the technical self-confidence questions were translated from an adaptive questionnaire (Combe, Harrison and Dong 2013), which was initially derived from the Subjective Technical Competence (STC) scale used by Arning and Ziefle (2007) and the Affinity to Technology scale (Wolters, et al 2010).

2.3 Social-cultural attributes

When collecting the user's data for inclusive design, in order to understand user profiles as much as possible, and their abilities of interacting with products and technology, it is necessary to draw wider considerations of users' information, including social and cultural background (Langdon, et al 2015). This kind of contextual data can help to clarify specific design context, and they are helpful in exploring influential factors that potentially affect users' report and performance when capturing user data. For instance, it proves that self-report measures (in terms of health and ability) can be affected by educational, cultural, language and social differences (Fors, Thorslund and Parker 2006). In this study, respondents' age, gender, educational qualifications, employment status, household income, living conditions (e.g. living alone or with the partner) and the size of living space were investigated.

2.4 Product interactions

A product interaction usually covers more than one specific capability, and it has been identified as an important component of collecting inclusive design data (Johnson, Clarkson and Huppert 2010; Langdon and Thimbleby 2010). Totally six product interaction tasks were involved in this study and the chosen tasks were all related to mobile phone operations. Mobile phones were selected for the basis of three primary considerations: a) mobile phones are popular among the target age group; b) multiple tasks can be performed and c) these tasks often cover more than one type of users' capabilities. Additionally, as a household survey, it can also help ensure a standardized test setting.

After two rounds of assessment, six interaction tasks were determined: 1) Sending pictures through social networking sites/APPs. In order to avoid floor effects, we chose Wechat in this study because it has been installed in more than 90% of smart phones in China and owned about 549 million users (Tencent Interim Report 2015); 2) Taking photos; 3) Texting and sending messages; 4) Making telephone calls; 5) Installing a SIM card and 6) Calling charges inquiry.

3. Findings and discussions

Respondents involved in this study ranged from 50 to 70. The mean age of the sample is 57(SD=5.2). In total, 130 valid samples from seven different cities and regions in China (South: Fuzhou, Shanghai, Nanjing, Nanchang; North: Lanzhou, Xianyang, and Yulin) were obtained and the investigations were carried out in different regions simultaneously during July and August 2015.The Basic information of the respondents was listed in Table 2.

Table 2 Review of the sample characteristics.

Age group	Percentage
50~54	34.6%
55~59	27.7%
60~64	26.9%
≥65	10.8%
Gender	Percentage
Male	46.2%
Female	53.8%
Education	Percentage
Primary school	3.1%
Junior middle school	23.1%
High school	38.5%
Secondary technique school	11.5%
Junior college	13.1%
Bachelor degree and above	10.8%
Living condition	Percentage
Live alone	3.1%
With partner	54.6%
With partner and children	36.9%
With children	3.8%
Other	1.5%
Employment	Percentage
Private	3.1%
The state-owned enterprise/ civil servants / research institutions	24.6%
Farmer	1.5%
Migrant workers	3.8%
Self-employed	50.8%
Retired	11.5%
Re-employment after retirement	4.6%

3.1 The effects of mood states

There is extensive evidence that affective state, such as mood or emotional state, can change people's perceptions, thoughts and behaviours (Forgas 2008). In the design context, a person's affective state will impact upon: a) users' perceptions of their own capability; b) their attitudes toward products/interacts; c) their actual capability with the products/interfaces and d) their actual capability with the product (Langdon, et al 2015; Norman 2002; Jordan 2000).

We adopted a short-version of POMS scale to measure respondents' mood states; the scale has been translated into Chinese and verified with good reliability (Zhu 1995). In our study, the results also show high reliability (Cronbach α=0.873). In this short Chinese POMS scale, eight modules (i.e. tension, depression, fatigue, confusion, anger, vigor and esteem) with 40 adjectives were presented to the participants and they were asked to choose the corresponding scores (1-5 points) that fit their mood states best in the latest week.

In the data analysis phase, the total mood disturbance (TMD) value was used to explore the effects of mood. TMD is a global estimate of affective state, calculated by first summing the scores for tension, depression, fatigue, confusion, and anger, then subtracting the sum of the scores for vigour and esteem-related effects, and finally adding a constant of 100（for the sake of eliminating negative values）. Thus, higher scores reflect a more negative emotional state (i.e. greater mood disturbance).

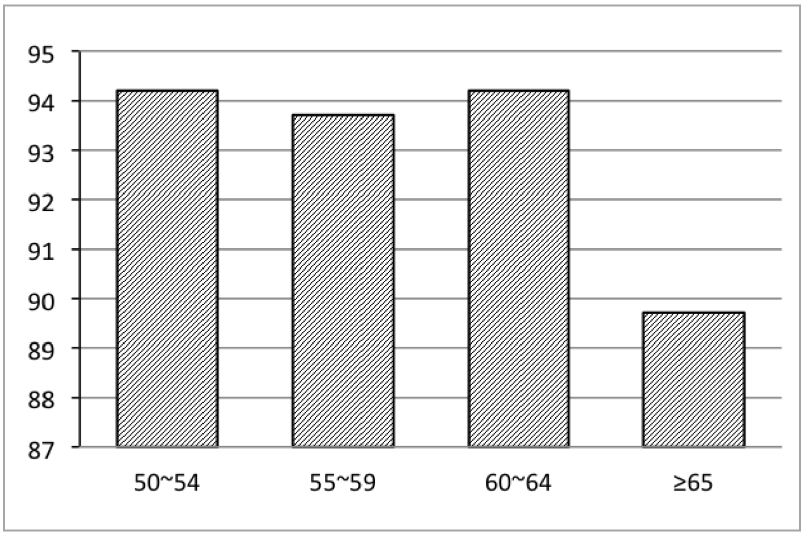

Figure 1 Comparison of TMD value in different age groups.

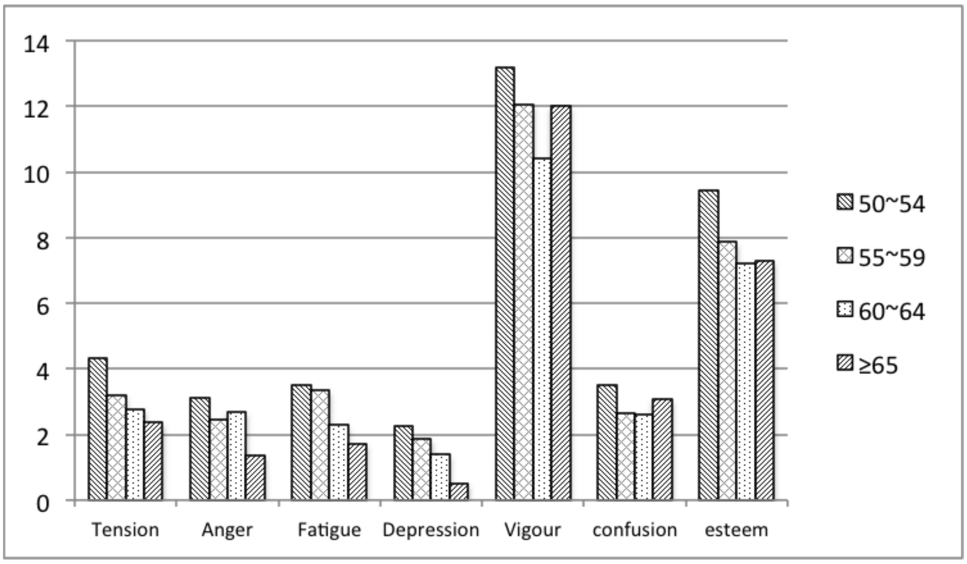

Figure 2 Comparison of seven modules of TMD values in different age groups.

As shown in Figure 1, the "≥ 65" age group shows lower TMD value than other groups; more specifically, older age groups reported higher scores in positive items and lower scores in negative ones (see Figure 2), which does not match the findings from other empirical studies (Gibson, 1997). This might be explained by the traditional family value of China: these people have entered the life stage of retirement and often enjoy taking some care of their grandchild. Much of the respondents in this group have shown higher satisfaction in their current lives and this could shed light on the lower TMD scores to some degree. The effects of mood states on the measurement of users' capability were investigated by analyzing different types of correlation coefficients in SPSS (Statistical Product and Service Solutions). The results show that mood states have significant impact on the older people's self-perceptions of their capability, more specifically, self-reporting results were significantly affected by the respondents' mood states. However, we did not observe significant impact of the mood states on older people's product interaction performances (in terms of whether the task was successfully completed or not), which are shown in Table 3.

Table 3 Correlation coefficients between mood states and self-reports/production interactions.

Self-reporting items	Correlation coefficients
Self-accessed health condition	- 0.35, p<0.01
Self-accessed vision	- 0.24, p<0.01
Self-accessed hearing	- 0.19, p<0.01
Self-accessed dexterity decline	0.20, p<0.05
Self-accessed cognition decline	0.23, p<0.05
Self-efficiency	- 0.25, p<0.05
Product interaction performance	Correlation coefficients
Installing a SIM card	-0.009, p=0.92
Making telephone call	0.013,p=0.88

Texting and sending message	-0.035,p=0.70
Taking a photo	-0.127,p=0.15
Sending a picture through Wechat	-0.201,p=0.22

It should be pointed out that in the product interaction performance task, we found that there existed many differences in the inquiring procedure among different regions of China, so “Calling charges inquiry” was removed from the final analysis to ensure a standardized test setting and credible results.

When considering the effects of mood states, the different results between self-reports and performance tests may imply that different mood states would influence users’ self-perception of their capability: better mood states indicate higher self-assessment of the capability, while mood states are not an influential factor upon the actual performance of product interaction based on the findings of our study.

3.2 Measurements of “comfortable vs. maximum” settings

In most cases, performance-based capability measures tend to provide an indication of maximum capability, which is not necessarily the most valid predictor of activities a person actually undertakes (Langdon, et al 2015; Porter, et al 2004; Simonsick, et al 2001). Datasets that establish on “comfortable” settings may help form more intuitive and accessible design guidelines. In our study, this issue was probed by asking respondents to perform the tests in both “comfortable” and “maximum” perceptions. Then the relations between users’ maximum and comfortable capability were explored by analyzing related data through SPSS. The differences were investigated by grip strength (in both dominant and non-dominant hand), visual acuity and visual contrast.

From the correlation coefficients analysis we can see that comfortable capabilities are correlated with maximum capabilities at different levels (Table 4). The maximum grip strength show moderate correlations with comfortable strength while comfortable visual capabilities weakly associated with the maximum ones.

Table 4 Correlation coefficients between maximum and comfortable measurements .

Testing items	Correlation coefficients
Grip strength (dominant hand)	0.61, P<0.01
Grip strength (non-dominant hand)	0.67, P<0.01
Visual acuity	0.43, P<0.01
Visual contrast	0.25, P<0.01

Additionally, there exist significant differences in the comfortable and maximum values between female and male participants (confirmed by nonparametric tests). In the grip strength tests, the mean value of comfortable grip strength is lower than the maximum and female shows lower performance than male. As seen in Figure 3, the variation ranges, determined by the minimum and maximum value, seem to be similar. However, in terms of the Std. and CV values (coefficient of variation), comfortable data show higher levels, indicating that the comfortable data has more dispersed distributions (Table 5). This may imply that the respondents have very different understandings of what is a “comfortable” condition. When capturing users’ capability data at a “comfortable” setting, it could be difficult to set up a consistent norm and to standardize users’ understanding of “comfortableness”.

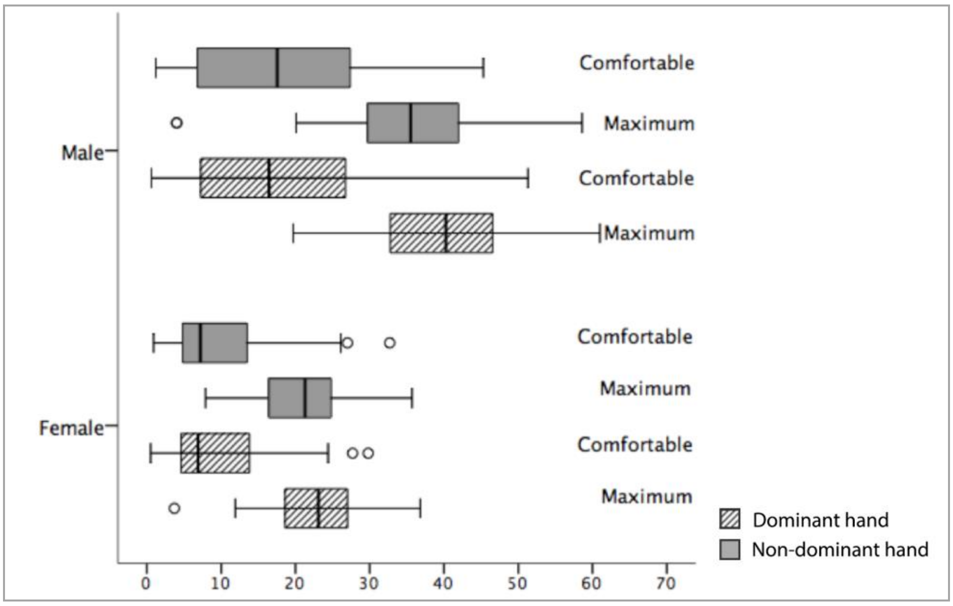

Figure 3 Mean grip strength of maximum and comfortable measurements.

Table 5 Comparisons of dispersion degrees of maximum and comfortable settings .

	Gender	Mean	Std.	CV
Dominant hand: Max	M	40.16	9.82	0.24
	F	23.05	6.49	0.28
Dominant hand: Comfortable	M	18.63	13.21	0.71
	F	9.82	7.30	0.74
Non-dominant hand: Max	M	35.08	10.94	0.31
	F	20.89	5.96	0.29
Non-dominant hand: Comfortable	M	18.49	12.08	0.65
	F	9.84	7.47	0.76

Since there are different perceptions and performances when measuring “comfortable” components, we conducted an exploratory analysis to find out whether there are valid relations between comfortable and maximum values. If any particular relations were verified, the models could be expected to be applied in current databases, which usually contain maximum measurements. Linear regression was conducted for female and male respectively, and the Enter model was used. Grip strength was adopted in the analysis and due to the weak correlations and the data type (ordinal scale), visual acuity and contrast measurements were not included.

As shown in Figure 4, for the comfortable grip strength of the dominant hand, the maximum grip strength value can predict the comfortable value at significant levels (male: $F=22.73$, $p<0.01$; female: $F=19.47$, $p<0.01$); for non-dominant hand, the linear model also account for the variance of comfortable values at significant levels (male: $F=25.36$, $p<0.01$; female: $F=26.86$, $p<0.01$). But it should be noted that the linear models could account for the prediction of comfortable values at moderate or even weak degrees (for the dominant hand, $R^2=0.369$; for the non-dominant hand, $R^2=0.452$). More effective predictive models are expected to be developed.

There is no consensus to inform respondents of what is the criterion of “comfortableness”: for example, in grip strength tests, some respondents may consider applying extreme slight force was “comfortable” while others held the view that as long as the force did not reach their limitations, it could be regarded as “comfortable”. These perceptions are in little accord with real product use scenarios. In addition, due to the moderate correlations between maximum and comfortable measurements, as well as the weak predictive power of linear models, it might be difficult to predict users’ comfortable states based on maximum datasets. Different approaches should be developed to capture users’ comfortable capability data. A future research direction may be to integrate the comfortable measurements into product interaction tasks. As combined performances of multiple functions, it may produce far better performance than summation of maximum capabilities would predict (Langdon, Persad and Clarkson 2010); at the same time, the relations (for example, valid analytical models) between “maximum” and “comfortable” yet to be explored for the reason that the measures of the component function on maximum settings are more reliable than measures of tasks or activities (Johnson, Clarkson and Huppert 2010).

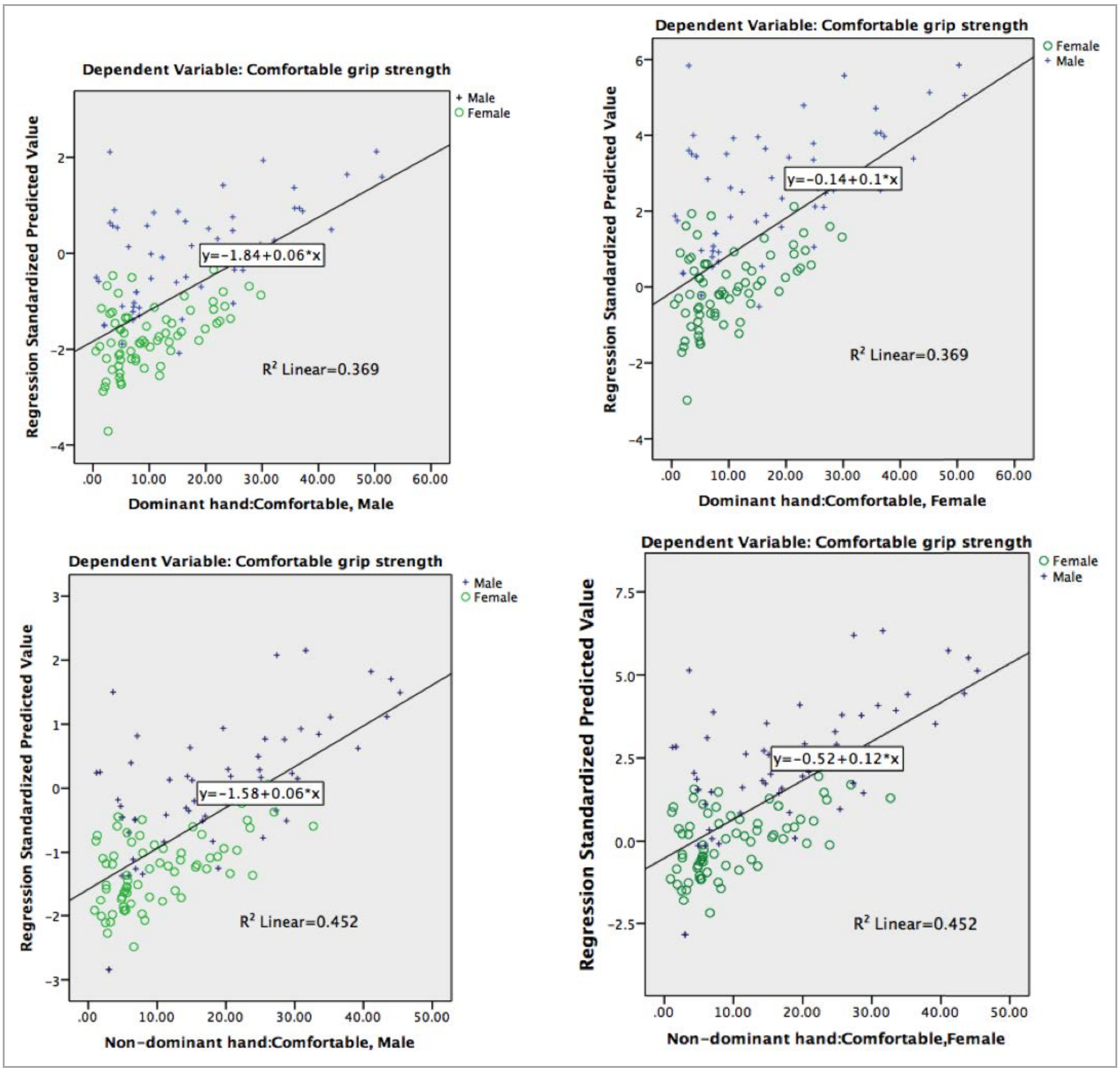

Figure 4 Linear regression analyses show that maximum grip strength could predict comfortable value at moderate levels.

3.3 Exploring predictive variables for product-interaction

As we are facing with ever-developing technologies, it will be unrealistic to develop a database that updates with the products and services change. Developing valid predictive models will significantly increase the feasibility and usability for offering guidelines to the design of a wider range of products, rather than the fixed products involved in this survey. Based on the data we have collected, an exploratory study was carried out to find effective predictors of different product interactions.

The analysis was executed in SPSS and the main methods were derived from the research conducted by Tenneti et al. (2012). In our study, we firstly divided all the variables into six modules, i.e. social-cultural data, vision, hearing, dexterity, cognition and psychological characteristics. And then, the results of product interaction tasks were processed: if the task was successfully completed, the corresponding result was encoded as “1”, and “0” if not. We did not count time taken as one criterion for the assessment of product interaction considering that “times are less useful in inclusive design than mainstream design, because people with limited capabilities often take longer to complete tasks” and “some older and less able users may prefer to take longer and be less rushed, and this does not necessarily indicate usability problems” (Goodman-Deane, et al 2014). Furthermore, time taken is not very useful because a short time could be a) due to the respondent completing the task quickly or b) due to the respondent finding they cannot do it at all and giving up quickly (Tenneti, et al 2012).

A multiple logistic regression approach was then conducted to find out significant predictors of successful product interactions. Forward model selection was used and odd’s ration value (“Exp (B) value” in SPSS) at a 5% significant level was adopted as the final selection criterion. All these five tasks were applied logistic regression analysis respectively and these six modules were used separately in every single analysis. Both odd’s ratio values and corresponding 95% confidence intervals were shown in Table 6. It can be seen that social-cultural variables, vision, hearing, dexterity, cognition and psychological characteristics can predict successful product interaction tasks at different levels.

Table 6 Significant predictors of successful product interactions at 5% significant level.

Product interaction task	Significant variables (at 5% significant level)	Exp(B)/OR	95% Confidence intervals
Sending pictures through SNS app (Wechat)	Age	0.83	0.76-0.95
	Income	1.53	1.13-2.06
	Self-assessed hearing	2.17	1.30-3.61
	Scenario-based report on hearing	1.50	1.07-2.07
	Self-assessed dexterity	0.40	0.20-0.80
	Self-reported frequency of computer use	0.60	0.37-0.98
	Self-reported frequency of Internet use	0.53	0.29-0.97
	Technical self-confidence	1.09	1.04-1.15
	Mood states	0.97	0.95-0.10
Taking photos by mobile phone	Age	0.81	0.70-0.93
	The size of living space	0.97	0.95-0.99
	Self-assessed hearing	2.14	1.28-3.60
	Self-reported frequency of mobile phone use	0.35	0.20-0.62
	Technical self-confidence	1.09	1.03-1.16
Texting and sending	Age	0.88	0.81-0.95

message	Performance-based visual acuity on "comfortable" set	1.55	1.03-1.30
	Performance-based visual contrast on "maximum" set	1.34	1.05-1.72
	Grip strength on "comfortable" set	1.05	1.02-1.09
	Self-reported frequency of computer use	2.17	1.25-3.78
	Self-reported frequency of Internet use	0.19	0.09-0.38
	Self-assessed cognitive ability decrease	0.51	0.31-0.84
	General self-efficiency	1.08	1.01-1.15
Making telephone call	Age	0.76	0.63-0.91
	Performance-based visual contrast on "maximum" setting	1.47	1.07-2.02
	Scenario-based report on hearing	2.27	1.27-4.07
	Self-reported frequency of mobile phone use	0.20	0.08-0.53
	Technical self-confidence	1.11	1.01-1.22
Installing SIM card of mobile phone	Gender	0.17	0.06-0.47
	Living condition	2.41	1.15-5.05
	The size of living space	1.02	1.00-1.03
	Performance-based visual contrast on "maximum" setting	1.27	1.03-1.57

Age is a significant predictor of four tasks in this survey and both self-reports and performance tests can effectively predict successful product interaction rates. It seems that the frequencies of technology products use could be significant predictors (in the tasks of "sending pictures through SNS app", "taking photos by mobile phones", "texting and sending message" and "making telephone calls") which may imply that by investigating users' frequencies of using products, users' ability of conducting related interactions could be indicated.

In the task of "texting and sending messages", the results of logistic regression show that the testing results of vision acuity (OR=1.55) and vision contrast (OR=1.34) could predict the task result at significant levels. It may due to the reason that the respondents usually tend to spend more time in observing and reading the information on the interface.

In addition, psychological variables show good predictive power, for example, the technical self-confidence in the tasks of sending pictures through SNS app (OR=1.09), taking photos by mobile phones (OR=1.09), making telephone calls (OR=1.11) and general self-efficiency in texting and sending messages (OR=1.08). Social-cultural variables appear in the analysis results of sending pictures through SNS app (income, OR=1.53), taking photos by mobile phones (size of living space, OR=0.97) and installing the SIM card (living condition, OR=2.41 and The size of living space, OR=1.02). It is interesting to note that factors thought to be correlated with the abilities of interacting with products, such as educational status, did not prove to be significant in this study.

Table 7 Significant predictors of successful product interactions at 1% significant level.

Product interaction task	Significant variables (at 1% significant level)	Exp(B)/OR	99% Confidence intervals
Sending pictures through SNS app (Wechat)	Age	0.85	0.75-0.91
	Income	1.70	1.22-2.60
	Self-reported frequency of Internet use	0.35	0.16-0.73
Taking photos by mobile phone	Self-reported frequency of mobile phone use	0.32	0.14-0.73
Texting and sending messages	Age	0.89	0.79-1.00
	Grip strength on “comfortable” set	1.06	1.01-1.12
	Self-reported frequency of Internet use	0.33	0.16-0.68
Making telephone calls	Self-reported frequency of mobile phone use	0.17	0.05-0.57
Installing the SIM card	None		

Finally, all the significant predictors of each task were analysed through logistic regression to find the strongest ones. A 1% significant level with 99% confidence intervals was used and forward model was adopted. Age and the frequencies of technology product use are retained and there is no significant predictive variable for installing the SIM card at 1% level.

The study suggests that we can make use of different types of user data by using the low-level functional capabilities to predict high-level task performance. Although it is difficult to measure user’s capability of interacting with products directly, it may be predicted by other factors. Furthermore, existing databases and data that collected for non-design purpose could also be taken into use.

4. Conclusion

In order to make design address the needs of a wider range of users, collecting end user data to support more inclusive products and services has become one of the primary research topics in the inclusive design research field. The findings from this study may help clarify some issues when capturing user data. Firstly, we find that the respondents’ mood states have positive effects on their perceptions of capabilities; better mood states indicate higher levels of self-report results, but no significant correlations were observed between one’s mood states and his/her actual product interaction performance. Secondly, data measured in "comfortable" settings were compared with those in "maximum" settings. The results show that, for grip strength, respondents may have dispersed perceptions of what is a "comfortable" condition. The linear regression analyses show that maximum values can predict the comfortable values at moderate levels. Lastly, we used multiple logistic regression analysis to explore some significant predictors for successful product interaction tasks. The results show that social-cultural variables, vision, hearing, dexterity, cognition and psychological characteristics can predict successful product interaction tasks at different levels. These predictive variables identified may offer references for the collection of new datasets in the future.

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'Difficult' packaging for older Chinese adults

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Abstract: The ageing of the global population highlights the need to understand the implications of declining user capabilities and to help elders live full, autonomous lives. One of the poorly understood issues is that of packaging openability. The aim of this study is to develop an understanding of packaging openability from older Chinese people's perspectives, so that packaging designers and manufacturers can address this issue effectively. A survey was conducted to rate the types of household packaging that consumers in the 60+ age group struggle with, covering opening gestures, coping strategies, attitudes towards packaging design and other related issues. The extent to which this group has difficulties when opening household products and packaging in connection with daily purchases was also discussed.

Keywords: packaging; openability; older adults; inclusive design

1. Introduction

As people get older, they become weaker and their dexterity decreases, making it increasingly difficult to open items (Sudbury-Riley, 2014). A lack of accessibility, intuitiveness or affordance, or clarification (information) and sometimes an excess of packaging have made it more difficult for older adults to access products (Dong, 2013; Passali, Gregori, & Foltran, 2012; Wang & Zhao, 2007; Winder, Ridgway, Nelson, & Baldwin, 2002; A. Yoxall et al., 2006). The age-related decline in capabilities has implications for design. The 60+ age group accounts for a growing proportion of the Chinese population. If reduced functional capability is not taken into account in the design process, this might lead to elders not being able to do their everyday tasks unassisted.

Data from the mid-2010 sixth national census from the Chinese National Bureau of Statistics showed that people aged 60 and older accounted for 13.26% of the total population (Wang, 2015). Designers may be failing to keep up with demographic changes, which will have implications for the autonomy of those who are joining the 60+ group.

In 2007, the *Consumer Reports* magazine (published in the United States of America) recognized the “wrap rage” phenomenon and created the Oyster Awards for products with the hardest-to-open packaging. At the same time, a survey in the UK magazine, *Yours* (McConnell, 2004), a magazine aimed at people over 50, found that 99% of the 2,000 respondents said packaging had become harder to open over the last 10 years, 97% said there was "too much packaging", and 60% reported they had bought a product designed with easier to open packaging. In fact, 71% of readers of the magazine said that they had hurt themselves as they struggled to open packaging. The Canadian Broadcasting Corporation (a public service television network in Canada) also handed out the first-ever Wrap Rage awards in Canada (2014). In 2011, the European Technical Specification for packaging (“ease of opening” CEN TS 15945) was published and was to be adopted as a British Standard in 2014 (BSI Group, 2011). It is likely to be used by consumer groups to report poor packaging and to lobby manufacturers for improvements. According to a British study (Winder et al., 2002), over 60,000 people receive hospital treatment each year as the result of injuries from opening food packaging. A study conducted by the Institute for Good Medicine (2009) found that 17% of adults over the age of 21 have either been injured at least once or know of someone who was injured while opening a holiday or birthday gift. In addition to physical problems with packaging, older adults experience psychological frustration and feelings of alienation (Sudbury-Riley, 2014).

Packaging openability data are fundamental to the design of safe, usable packaging. There are already several studies about packaging openability for older adults (Brooks, 2013; Clifford, 2013; Jégou & Liberman, 2012; Khanom, 2013; UK Food, 2013; Wisson, 2012; Yan & Yu, 2005). These authors make use of data collection, statistical analysis using various measures including self-reporting, and performance assessment (Bell et al., 2013; Brooks, 2013; Rowson et al., 2014; Sudbury-Riley, 2014; Wu, Wu, Liang, Wu, & Huang, 2009; Yen, Flinn, Sommerich, Lavender, & Sanders, 2013; A. Yoxall, Rodriguez-Falcon, & Luxmoore, 2013). However, the currently available end-user capability databases have weaknesses. There is a lack of surveys with an appropriate level of specificity in the questions, and the data suffers from being derived from a non-representative sample of household products. The vast majority of packaging-related work has looked at dexterity issues related to the strength of consumers when opening jars. Moreover, most of the research was conducted in western countries. Studies from China are relatively few in numbers (Ke, 2009).

The aims of this study include the following. First, it investigates what types of packaging cause severe issues of openability and what problems ageing Chinese consumers actually come across when opening household packaging. Second, it explores ageing consumers’ attitudes to household packaging currently in the Chinese market to better match products with user needs and requirements.

2. Methods

2.1 Pilot Study

To understand a general picture of existing packaging openability issues, a pilot study was conducted. One hundred older people (50% male and 50% female) between the ages of 50 and 80 (mean of 61.3 years) in four different cities in China were interviewed in the pilot study. They were asked to participate in a 20-minute face-to-face interview. After some basic information about the subjects was recorded (age, gender, whether in charge of shopping in their household), the formal interview began. The interview covered topics including the need for help when opening packaging, the five cases of hardest-to-open packaging in their daily lives, how hard each item was to open, the reasons for bad openability and the interviewees' general attitudes towards household packaging design. A "total packaging score" was calculated as a measure of how difficult or easy each person found it to open the specific types of packaging mentioned in the interview, using a summation of the Likert ratings provided for each individual packaging type (-2, "very easy"; -1, "easy"; 0, "neither easy nor difficult"; 1, "difficult" and 2, "very difficult"). A series of cards with photographs was used in conjunction with questions to eliminate any ambiguity regarding packaging types.

2.2 Survey

In order to determine the factors that were crucial to improving packaging openability, a survey consisting of three parts was conducted in addition to the pilot study. This survey utilized both quantitative and qualitative data collection tools. Data collection consisted of a semi-structured interview, performance test and video record as well as pictures taken from older people's daily lives. Participation was voluntary and anonymous. A total of 130 questionnaires were distributed to randomly selected adults of 50–70 years old to ensure a sample group with an even spread of socio-economic backgrounds. The sample comprised 60 males and 70 females with a mean age of 57.4 years. The subjects were from six cities and towns across China, recruited using convenience sampling at shopping centres, parks and retirement villages. All participants had the ability to live independently.

There is extensive evidence that affective states such as moods or emotional states can change perceptions, thoughts and behaviours. So all tests were conducted in participants' homes. Before the start of the test, the interviewer engaged in small talk with the participants to "break the ice" and help them overcome any discomfort from being interviewed by the researcher and to maintain a "normal" mood. Ethical procedure would be followed afterwards. After recording some basic information about the subjects (age, gender, level of education, living arrangements, employment status, health status, whether they had arthritis), we conducted the formal interview.

Based on the pilot study, and also considering that packaging to be surveyed needed to be portable (as the researchers will take them to the participants' homes), four different types of packaging were selected for this survey, including a jar, a thin film pack, a bottle with a ring pull and a shrink-wrap pack (Figure 1). These types were regarded as “difficult to open” packaging, or “harsh” packaging by the participants in the pilot study.

Jar	Thin film pack	Bottle with ring pull	Shrink wrap
13.2cm (H)*6.5cm (D)	4.5cm (H)*2.3cm (D)	10cm (H)*2.9cm (Top-D)/6cm (bottomD)	13cm (H)*1.8cm (D)

Figure 1 Selected packaging for this survey

The survey comprised of three parts:

The first part: recording the motion patterns. All participants were asked to open the four different types of “harsh” packaging, and 20 cases were video-recorded. The time was also recorded. The participants performed the following test procedure in the position which they thought to be comfortable and which was frequently used in their daily lives. They were allowed to use assistive tools at their home during the opening process, but they were requested to try opening the packaging first of all with their bare hands.

The second part: collecting ratings. After opening each type of packaging, participants were asked to rate the household packaging. If they thought it was hard to open, they were asked to select reasons. A 5-point scale was used to collect this information (with labels of -2, “very easy”, -1, “easy”; 0, “neither easy nor difficult”; 1, “difficult” and 2, “very difficult”). Seven “barriers” in performing the opening of packaging were presented to participants (all were multiple choices), including: do not know how to open; size hard to grasp; bottle/closure too slippery to gasp; need high skills; tedious open steps; need great strength; and need tools. These barriers were collected from the pilot study. Participants could also add other reasons that might result in issues with opening the packaging.

The third part: collecting older adults’ perspectives related to packaging openability. Participants were asked to indicate with labels of “very unimportant”, “unimportant”, “little improtant”, “important” and “very important”) the importance of package openability in affecting household purchasing, whether they ever needed help to open packaging, what opening strategies they might use and their suggestions and perspectives towards recent household packaging. Injuries sustained during usage of a package were noted and described. Besides each option provided, participants were allowed to add their own.

3. Results

The data received from the participants were coded by assigning a number to item on each scale. Numerical data were then analysed using SPSS (Version 10.SPSS Inc, Chicago, IL, USA).

Frequencies of responses were calculated for each question. ANOVA was used to determine the relationships between various numerical variables using SPSS. A result was considered to be significant when $p<0.05$.

3.1 Pilot Study

Over half the participants (70%) came from families where women were in charge of daily shopping, and they reported more difficulties and scored higher than males; this result was the same as those reported in previous studies (Brooks, 2013; J. Claudio, de, la, Fuente, 2013; Marks et al., 2012). However, age did not make a significant difference in the rating ($p>0.05$).

It was identified that corks, jars, traditional white wine packaging (defined as "Fiddly Packaging"), drink cans, bottles with pull-up rings, clamshells, shrink-wrapped packaging, aluminium plastic closures, crown caps, thin films and seal thread were hard to open (Figure 2). After the participants' difficulties were analysed, it was found that hard-to-open packaging was considered inaccessible, in general, for one or a combination of the following reasons: did not know how to open, size influenced the grasp, the bottle/closure was too slippery to grasp, opening the packaging required high skills, the steps to open were tedious, great strength was needed and tools were needed.

Figure 2 "Difficult" Packaging Identified by Older Chinese Adults

3.2 Survey

Table 1 shows the participants' characteristics. Most (97%) of the participants live with others. Twenty males and 50 females are currently unemployed (i.e. retired or unable to work). Most (84%) participants thought their level of health was intermediate.

Table 1 Participant characteristics

		Male (n=60)	Female (n=70)
Age	50-59	25	17
	60-69	35	53
Education	Primary school	1	3
	Junior high school	14	16
	Senior high school	23	28
	Junior college	14	19
	Bachelor	9	5
Living Arrangements	Alone	2	2
	With others	58	68
Employment Status	Currently employed	40	20
	Not currently employed	20	50
Reported Arthritis	Yes	8	15
	No	52	55
Health Status	Very good	9	9
	Good	26	31
	Ordinary	23	29
	Bad	3	1
	Very bad	0	0

First part

Yoxall et al. (2008) defined different types of grip strength when opening packaging (Figure 3).

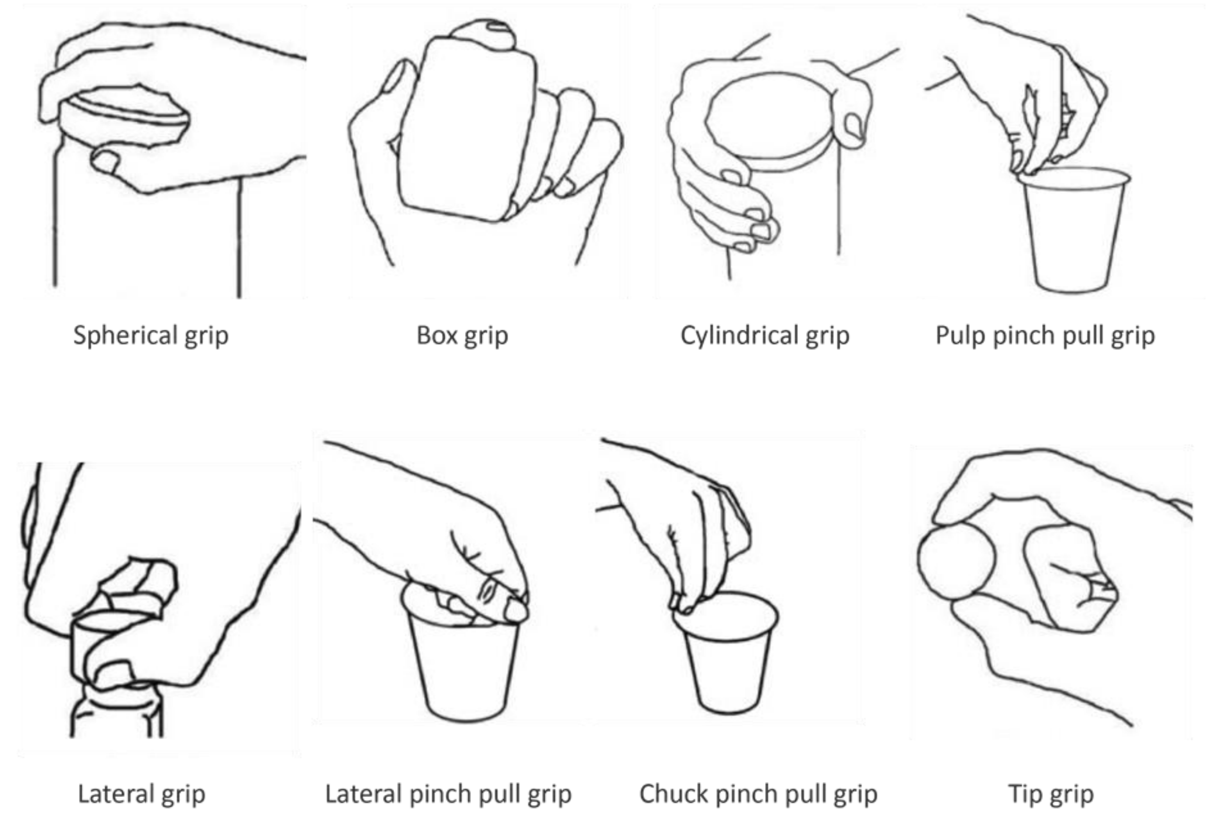

Figure 3 Types of grip strength (Yoxall et al., 2008)

The still photographs showing each of the operant types adopted throughout this study were derived from the video recordings to facilitate the analysis. After analysing the video tapes, motion was analysed. Opening the thin film pack required the greatest number of motions, while jars needed the fewest combinations of motion. The time needed to open the bottle with a ring pull was significantly longer than for other packages. The average time taken to open a package was 18s. 92% participants preferred to stand up when opening packaging. 65% of them used tools while opening the packaging; these ranged from scissors (79%), screwdrivers (44%) and teeth (38%) to bottle openers (12%), pliers (9%) and knives (8%).

Table 2 Results from the first part

Packaging Type	Average opening time of 130 participants (s)	Motion analysis of 20 video-recorded cases
Jar	16.35	Box grip (14 cases out of 20, i.e. 14/20); Spherical grip (3/20); Cylindrical grip (3/20)
Thin film pack	16.34	Lateral grip (20/20); Pulp pinch pull (10/20); Figure stab (5/20); Chuck pinch pull (3/20); Lateral pinch pull (1/20)
Bottle with ring pull	28.84	Pull (20/20); Chuck pinch pull (17/20); Pulp pinch pull (12/20); Lateral pinch pull (9/20)

Shrink-wrap	14.76	Pulp pinch pull (14/20); Chuck pinch pull (6/20); Lateral pinch pull (4/20); Lateral grip (3/20)

Second part

In total 92% people struggled with shrink-wrap packaging, and it was given the highest score for being hard to open. Around half of the people used tools when opening shrink-wrap packaging. They rated this packaging as hardest to open mainly because they did not know how to open it (97.3%), they needed great strength to open it (87.2%) and the closure of the packaging was too tight (73.2%). In contrast, opening a thin film pack did not require much assistance from tools. Judging from the video, people appeared to use their fingernails as “tools” to open thin film packs.

Table 3 Results for packaging opening

Packaging Type	Mode Score	Average Score	Use tools (%)	Reasons for being hard to open*
Jar	1	1.08	32.5 (11.7 give up)	4， 6， 3
Thin film pack	0	0.72	13 (1 give up)	4， 7
Bottle with ring pull	0	0.75	24 (5 give up)	4， 8
Shrink-wrap	1	1.76	50 (7 give up)	1， 6， 7

*1= do not know how to open; 3= bottle/closure too slippery to gasp; 4= need high skills; 6= need great strength; 7= closure too tight; 8=cannot tear the film

Third part

Thirty-seven out of 130 participants reported that they turned to someone else for help with opening a package. Twenty-four out of the 130 participants reported that they once hurt themselves when opening a package. Sixteen per cent of participants said the openability of packaging had an influence on their purchase decisions. The three biggest problems with respect to packaging openability were as follows: opening required high skills (97%), a lot of strength was needed (89%) and it was not clear how to open the package (78%). Participants also provided other reasons for viewing packaging as inaccessible: 35% of participants thought that the pull-up ring was an unreasonable design and that it was easily broken. Some thought it was too tiny, which made it impossible to pull up, and 3% of the participants were worried about spilling or wasting the product. Over half of participants (56%) said that openability had some influence on their purchasing decisions (Table 4).

Table 4 How does packaging openability affecting elder adults' purchasing decisions?

Level of influence	Percentage
No influence	12%
Has little influence	24%
Has some influence	56%
Has considerable influence	8%
Has very great influence	0

4. Discussion and conclusions

Prior studies of packaging tend to concentrate on narrow and specific issues. For example, previous marketing studies tended to focus on brand communication (Liao, Corsi, Chrysochou, & Lockshin, 2015), ergonomic literature on physical issues (Canty, Lewis, & Yoxall, 2012; Rowson & Yoxall, 2011) and food science literature on nutrition and consumer education (Velasco, Salgado-Montejo, Marmolejo-Ramos, & Spence, 2014), while others focused on public policy implications (Auttarapong, 2012). This study takes the viewpoint of elderly consumers and provides comprehensive perspectives towards packaging openability from older adults.

The study also brings the concept of inclusive design into the packaging literature. Inclusive design is about maximizing the market potential of products. This makes obvious business sense, but this concept has until now been limited to the design and ergonomics literature.

Chinese Pharmaceutical Packaging Association in 2015 reported that over 95% of pharmaceutical packaging did not have Child Resistant Cap (CRC) closures; however, CRC was always ranked as the hard-to-open packaging in previous studies (Dong, 2013; Marks et al., 2012; Rowson et al., 2014; Ward, Buckle, & John Clarkson, 2010), this study did not include this type of packaging. An obvious cultural difference was observed: corks for red wine were considered by older Chinese adults as the hardest packaging to open. When the participants were asked about cork packaging, most of them thought it was too hard to open, even with corkscrews. We surmise that this may be because they were not acquainted with the tool, which not only made the opening process tedious but also required considerable strength.

It was interesting that when participants were asked for their perspectives on packaging openability, there was an interplay between subjective and ergonomic factors. For example, textured surfaces which offer a better grip can be taken to indicate that the bodies of bottles are difficult to remove from packaging, whereas smooth, rounded shapes, which are less easy to grasp, may be preferred because they appear more soft and friendly. Therefore, ergonomic factors are not the sole determinants of customer-friendliness and ease of use. Participants also showed a negative attitude towards packaging that had strange shapes; for example, in this study, the bottle with a ring pull was the least popular shape. Most (86%) thought its shape had an adverse influence on grasping, and they could hardly hold the package during the opening process due to its irregular shape.

Prior studies mainly focused on discussing the strength people need while open packaging (Table 5). However, opening packaging requires more than just physical ability. Besides manual function, cognitive and perceptual factors (hand-eye coordination and sensitivity) are important when opening consumer products. It is easy to see from the results that factors such as the visibility and simplicity of the opening mechanism play important roles in the ease of opening a packaging. For instance, in this study, opening skills were considered the biggest problem when opening a difficult package. From the results of this study, opening skills needed to open packaging should also be studied and be given priority when designing packaging.

Table 5 Previous studies on the subject of packaging openability

Ability	Percentage	Literature
Perceptual ability (Visual perception; Affective perception; Fingertip perception; Communication Evaluation)	17.2%	(Chihara & Yamazaki, 2012; Chihara, Yamazaki, Itoh, & Han, 2009; Clement, Kristensen, & Grønhaug, 2013; Han, Nishiyama, Yamazaki, & Itoh, 2008; Keates, 2006; Luo, Fu, & Korvenmaa, 2012)
Cognition (Intellectual functioning; Logical)	13%	(Caner, 2010; Duizer, Robertson, & Han, 2009; Kozak & Terauchi, 2003; "“Opening Up” and “Closing Down”," 2008; Winder et al., 2002)
Physical ability (Vision; Dexterity; Finger friction; Pitch strength; Grip strength; Twisting force; Muscular strain; Reach and stretch; Mobility; Kinematics)	67%>*	(Bush, Bix, Bello, & Fair, 2013; Caner & Pascall, 2010; Carse, Thomson, & Stansfield, 2011; Chang, Ho, & Su, 2008; De la Fuente, 2013; Clement et al., 2013; Crawford, Wanibe, & Nayak, 2002; Rahman, Thomas, & Rice, 2002; Kozak & Terauchi, 2003; Kuo et al., 2009; Lewis et al., 2007; Marks et al., 2012; Fowler, 2001; Saha, 2005; Su et al., 2009; Torrens, 2001; Voorbij & Steenbekkers, 2001; Winder et al., 2002; Yiangkamolsing, Bohez, & Bueren, 2010; A. Yoxall, Luxmoore, Rowson, Langley, & Janson, 2008; A. Yoxall et al., 2013; B. A. Yoxall, Langley, Janson, Wearn, & Manson, 2006)

*There are actually more articles for physical ability; we have not listed them all.

Packaging that was defined as “difficult” usually needed between 14.76 s and 28.84 s to open. This may suggest that if the opening time for packaging is beyond 14 s, it will probably be identified as “difficult” packaging.

Similar to previous studies (Thomson, Carse, & Stansfield, 2007; Dong, 2013; McConnell, 2004), older people use many sharp tools, such as scissors and screwdrivers, to help open packaging. Some of the alternative strategies mentioned involved a high level of danger.

Unfortunately, during our research, three out of 130 participants hurt themselves when using knives and scissors for package-opening tasks. Shrink-wrap packaging (50%) often requires tools and was given the highest average mark (1.76) for being hard to open. But this type of packaging also took the least time to open. It seems that the opening time does not have as much influence on people's judgement of "difficult" packaging as does the issue of whether people have to use tools to open it.

The ageing population in China requires greater attention than it currently receives from the market. Fifty-six per cent of participants said that openability had some influence on their purchasing decisions (Table 4), and some even said that it might make them switch brands. Eight per cent said that openability had a great influence on their purchasing decisions, and they refused to buy the frustrating products again.

Compared with the Baby Boomers, who are less tolerant of brands that fail to cater to their needs than were previous generations (Sudbury-Riley, 2014), older Chinese adults are much more lenient with all packaging. When asked about the difficulties when opening packaging, many of them said they should prepare a tool such as scissors for opening the packaging, and they were satisfied with most products. "Compared with old days, when we lacked basic living substances, we are already lucky today!" said one respondent. Most of them accepted the fact that there would be certain tasks they struggled with as they aged. When problems occurred, they thought that they should blame themselves first rather than the products.

The concept of "avoiding extremes" had a great influence on participants' responses. Having a moderate attitude is an ancient Chinese concept of the Confucian school, which advocates that people should be neutral and hold their opinions when dealing with issues. When the participants were asked what they thought of the packaging openability, many of them would say, "Oh, I know this one, it was so difficult to open", but when they were asked to rank the difficulty, they would choose "has some difficulty"; only a few of them would choose "very difficult" to describe their feelings.

Although the prime function of packaging is to protect contents, with the ageing society, manufacturers are encouraged to produce consumer-friendly packaging that will promote greater overall consumer satisfaction. Difficult packaging will put off ageing consumers, while easy-to-open packaging will benefit all.

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Crafted with Care: Reflections from co-designing wearable technologies with care home residents

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Abstract: With increasing longevity and changes in population demographics; designers, engineers and architects are faced with the challenge of providing older adults with enabling technologies and home environments that facilitate physical activity and wellbeing. To promote acceptance and adoption, making these technologies more desirable and less stigmatizing is crucial. In this paper, we outline a craft-based co-design methodology that we developed working with groups of care home residents designing wearables for research. The research asks care home residents to wear activity-monitoring devices to provide insight into the ways they currently utilise their spaces and where improvements could be made. We propose that a craft-based approach allows designers to understand and uncover people's capabilities and needs in a non-intrusive and empathic way. Our findings show that using this approach enabled creativity, confidence and connectedness amongst participants. We discuss our reflections and insights that have implications on the approach and future work.

Keywords: Wearables; Ageing; Craft; Co-design

1. Introduction

The 'oldest old' are the fastest growing demographic in UK society. With increasing longevity, changes in our capabilities due to age or disease could cause us to lead less physically active lives. Research has shown that regular physical activity is an important measure of health and function in later life (Talbot et al., 2002). Unfortunately inactivity is particularly common amongst older people. Accelerometry data collected in England showed that only 6% of men and 4% of women over the age of 75 years reach current physical activity recommendations (NHS Information Centre for Health and Social Care, 2008). Furthermore, in care homes around Britain, 78% of men and 86% of women were classified as inactive. This is twice the number of people living in private homes according to the British Heart Foundation (2014). Physical activity in older people can have many health benefits including fall prevention and mental wellbeing. Furthermore when physical activity increases in old age, physical abilities can be maintained or even improve (Fiatarone et al., 1994).

With ageing and the accompanying change in capabilities of older people, an increasingly important consideration is the emerging requirements for our built environments that meet the needs of the older population (McIntyre and Hanson 2013). Architects and designers alike face the challenge of creating enabling home environments that support the changing needs of users and promote independence for as long as possible. Successful design can make major contributions to maintaining or increasing physical independence for older adults and ensure that physical impairments are not a disability (Clarkson et al., 2003).

The context of this work is the BESiDE project which addresses challenges brought about by people living longer and the growing number of people spending significant time in residential care homes. The overarching aim of the research is to inform better building design that promotes greater mobility, physical activity and social connectedness and therefore wellbeing and better quality of life among care home residents. To achieve this aim body-worn location based and accelerometer technology is being used with local participating care homes to determine how well older adults living in care homes currently negotiate and utilise spaces within their built home environment.

Presently, little data is available on everyday physical activity for our oldest old or care home resident populations and self reported physical activity such as walking is known to be inaccurate (McMurdo et al., 2012). Whilst activity-monitoring devices can facilitate knowledge about movement, older wearers may perceive them to be ill fitting, unattractive, unfamiliar or associated negatively with “medical equipment” therefore inhibiting adoption. According to Turner and McGee-Lennon (2013) although the range of telecare technologies (which includes activity monitoring devices) that cater for a range of physical, health and social needs is increasing, the uptake for them is still low. Challenges that affect the uptake include the lack of consideration of different stakeholders, inappropriate functionality and interaction, not being able to personalise the technology as well as ethics and privacy issues.

To engage and include older people, not as subjects but active participants and stakeholders in the design of activity-monitoring devices or indeed any wearable technologies for health care, it is crucial to involve them in the early stages of design to gain insights that would shape products that are useful and appropriate for them. This is particularly important if we want the technology to benefit the wearers but also ensure that they adhere to wearing the technology so that the data collected is reliable for the researchers to analyse.

2. Related work

2.1 Wearables

With a focus on care home residents, various studies such as those by Hocking (1999) and Leger and McCaffery (2014) have suggested that between 50% and 56% of wearables and assistive technologies respectively are abandoned by older or vulnerable adults and 15% are never used. Furthermore, Ofcom (2015) conducted a survey revealing that no adults above the age of 65 years (sample size of 461) use wearable technology at home or anywhere else. Reluctance to adopt has been attributed to a lack of empathy between designers and users as many wearables are regarded as passive monitoring devices 'to keep you safe' and therefore viewed negatively by potential older users (Bryson, 2014).

Wearables have been researched and implemented in past health-related projects. For example SMART, which later became TARGET Stroke Exerciser after a merger with Philips Research, created wearable sensors with a focus of at home rehabilitation (Saini, 2008). Stroke patients wore a vest with sensors and an armband to link to a computing unit where patients could visualize their exercise progress on screen, compare with previous results and prepare future treatment plans. It was reported that by taking a user centred focus, the system successfully encouraged participating patients to engage more frequently in their home rehabilitation exercises although the wearables are bulky and may require additional aid to put on and take off. The vest and armband also look like medical apparatus. Whilst this may not be a negative factor in the context of home rehabilitation tools that are worn for a specific task for a short period of time during the day, an aesthetic such as this would not be apt for a care home study where residents will wear them for 5 days during waking hours, and should be unobtrusive and be worn easily in conjunction with resident's other clothing. Bodine and Gerperle (2003) in particular stressed that the acceptance of wearable devices depends on design for comfort and functionality and must be considered early in the design and development process. In particular their study found that there is an interplay of functionality, desirability and location of the device on the body. They stress that the functionality and benefits of the wearable need to be clear in order for acceptance and adoption of the technology. Where the technology is located on the body can play an important role in acceptability. Profita et al. (2013) did a study on the societal perceptions between Americans and South Koreans of six body locations (collarbone, torso, waist, forearm, wrist and pocket) for the placement of an e-textile input controller and found that culture plays a part where the preferred location should be. For example, the waist area for an American male and the collarbone and torso area for an American female are locations where the placement of a controller would be less acceptable. For South Koreans females, only waist and forearm areas are acceptable areas while South Korean males have no issues with any placement locations. Working with visually impaired people on wearables, Ye, Malu, Oh and Findlater (2014) found that mainstream designed small, easily accessible yet discreet (wrist, ring or necklace) wearable could positively impact its use as well as help facilitate in the participation of social interactions.

2.1 Designing with care homes residents

One important question is how do we co-design wearable technologies with older people in care homes. Although there are many methodologies reported by researchers working with older people in HCI such as Frohlich, Lim and Ahmed (2014) and Newell, Arnott, Carmichael and Morgan (2007), our literature review indicated only a few design studies (for example Blythe et al. 2010 and Gaver et al. 2011) and methodologies for working with care home residents. Our informal visits to participating care homes and meetings with staff and residents revealed the varied and significant cognitive and communication issues that may impede the resident group's engagement with the design and research; one carer suggested that "maybe 90%" of the residents suffered some degree of cognitive difficulty and may therefore struggle to understand the design intention. Staff should act as guides within the recruitment process to assess individuals' ability to participate. Other psychosocial effects that may affect older people in a workshop setting, for example, could include tiredness, lack of stamina, concentration, attention and motivation, slow responses and tendency to get sidetracked in conversation (Barrett et al., 2000; Newell et al., 2007). Several authors address these challenges by working with older partners in multiple stages over time (Demirbilek and Demirkan, 2004; Luck, 2007). It is important therefore to find innovative and user-centric ways to combat barriers in personalising technology. Barriers could include the lack of understanding of technology, which contributes to low levels of engagement particularly in the context of care home life as digital devices are often considered to be inappropriate or unnecessary (Dykes, 2013). Cognitive and generational issues may also further impede the understanding of technology in particular the effects of cognitive changes in aging and formative experiences by different birth cohorts with technologies that they have used could impact on the way older people understand and interact with current products (Lim, 2010).

As participants involved in the BESiDE project are required to wear activity-monitoring devices for several days, it is imperative that users are involved in the design of the carriers or wearables that house the activity-monitoring technology. Research by Norton, Mochon and Ariely (2011) has shown that people who are empowered to make their own objects or have a voice over the design tend to value them. Making and crafting have been part of people's lives and although it has been related to professions such as jewellery and metalsmithing, nowadays people have turned to crafting for recreational purposes. Rosner and Ryokai (2009, p195) describes that crafting is seen as a "partnership between people and technology for the creation of personally meaningful things". By empowering users to express their ideas and preferences and be involved in the designing of the wearable could potentially lead to better adoption and adherence of the technology and eventual study.

3. Methodology

Building on Szebeko and Tan's (2010) co-design methodology, we developed a progressive programme of design activities and materials to inspire, create and personalise wearables for the participating care home residents. Designed to encourage participation and understanding of residents' needs and preferences, the activity programme comprised of initial informal visits with crafted samples, crafting activities and later, more structured design sessions.

3.1 Approach

Taking a craft approach, we devised a set of activities to engage residents with familiar materials and skills to design and personalise appropriate carriers for the sensor technology. In collaboration with staff, we tailored informal crafts activities sessions as well as more structured design sessions (co-design workshops) to suit the resident group (Figure 1). The informal craft sessions were hosted to enable staff, residents and researchers to get to know one another better and set the scene for the design activities. Informal craft activities typically last for two hours including tea breaks. We typically have 3 to 4 craft sessions introducing activities such as making fabric pictures and sessional cards. After the informal craft sessions, co-design activities were introduced to residents who were able and wanted to explore the development of wearables more fully and potentially take part in trialling the technology. At the start of the co-design sessions, the design process, methods, materials and example sensors were introduced and the brief explained to residents with the aid of a pictorial booklet. In addition, we created bespoke design tools including activity sheets, mood boards and a picture card deck of examples of wearable objects and fastenings to support residents in defining initial design requirements throughout the co-design process.

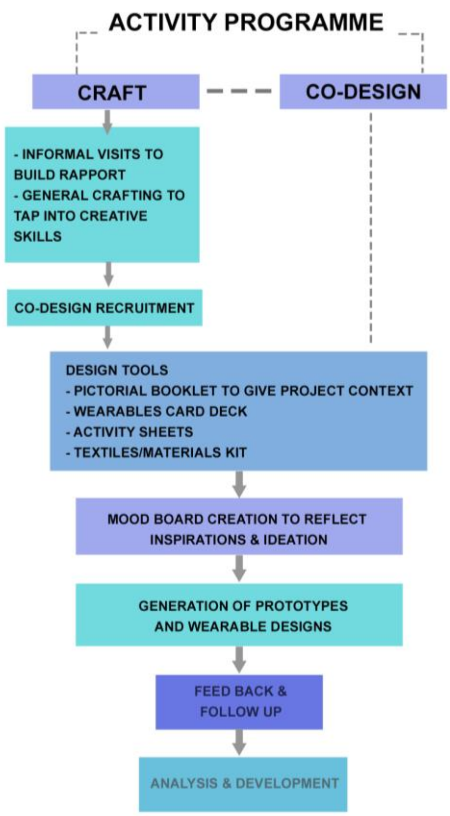

Figure 1. Progressive activity programme and use of project design tools.

These co-design activities were conducted over several weeks and depending on the participant's constitution, each session could last between 20 to 40 minutes. If any participants were unwell the sessions would be rescheduled or revisited with the resulting activity then taking place sometimes two to three weeks later. During the course of the project we also visited the residents informally, taking part in their in-house activities or have a chat with them over tea.

3.2 Materials

Everyday and familiar crafting materials (Figure 2) including buttons, yarns and textiles were used within the informal crafting sessions to explore aesthetic and textural preferences. Choosing from a sample set of textile swatches consisting of everyday, special occasion, athletic and health focused textiles, (e.g. polyester, silk, neoprene), a group of 6 older adults aged 65 and over with experience of care homes (for example as visitors or ex-staff) favoured cottons and wools as fabrics such as these are familiar and common within an older adults' everyday wardrobe and were therefore expected to be more readily accepted for incorporation into wearable designs.

Figure 2. Materials chosen for used in the informal crafting session were in response to consultation with older adults aged 65 and over who were staff, volunteers or have loved ones living in care homes.

These materials were used within the co-design sessions in conjunction with a range of design tools which included a body location card to explore ideal placement of potential wearables, a pictorial card deck showing examples of wearable objects and fastenings, (allowing us to explore possible styles and functionality), and activity sheets; "Getting to Know You", "In my Wardrobe", "My Textiles and Accessories" and "My Design Features" (allowing us to capture personality, values, and inspiration). The aim of using these tools was to help residents' articulate their preferences and express their creativity. This culminated in the creation of personalised moodboards to visualise their design narratives. Reflecting on these also allowed residents to reflect on their developing design choices and rationale. (Figure 3).

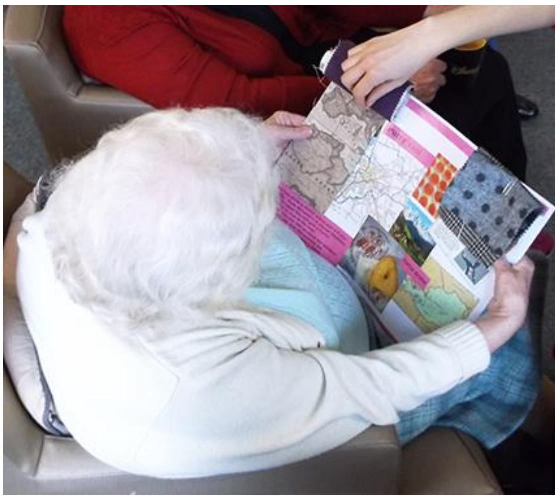

Figure 3. Reflecting on design narratives using personalised mood boards.

3.3 Participants

14 participants (Table 1) aged 65 years and over were recruited from three participating care homes' resident groups. Identified as cognitively able to take part in the research by staff, residents were introduced to the research by way of informal visits and presentations where the researchers used picture cards and example wearables and craft materials to explain the context and intention of the research activity. Residents were invited to voluntarily take part in the research and making sessions. Residents who agree to participate were provided with participant information sheets at the beginning of each co-design activity as well as an informal briefing by the researchers to ensure clarity and understanding. Support was given as required by care home staff for example a staff member helped to relay our discussions to a partially deaf resident to ensure his understanding. Residents were assured that they could participate as little or as much as they felt able and happy to, with the option to opt out at any time. Informed consent was sought and obtained from all participants.

Table 1 Participant Profiles

Participant	Age	Gender	Marital Status	Occupation prior to retirement	Additional Health Factors
P01	84	F	Widowed	Housewife/farmer	N/A
P02	88	M	Widowed	-	Partially deaf/ Walking aid user
P03	94	M	Married (Living with spouse)	Royal Navy	Wheelchair/Walking aid user
P04	83	F	Married (Living with spouse)	-	Walking aid user

P05	74	F	Married	Admin at a media publishing company	Recovering from stroke
P06	79	F	-	Teacher	Visually impaired
P07	92	F	Widowed	Artist	Hard of hearing
P08	79	F	Widowed	Teacher	Aged related cognitive decline
P09	79	M	Married (Not living with spouse)	Civil Engineer	Mild cognitive impairment
P10	90	F	Widowed	Dance Teacher	Mild cognitive impairment

3.4 Analysis

During the crafting and co-design sessions, we were immersed in conversations and provided support for the activities we arranged. From observations and conversations, we took notes and photographs wherever appropriate. The documentation included informal notes, audio recordings of discussions and transcriptions, worksheets and photos of craft materials. Through sharing these notes, study of photos and worksheets and in-depth discussions among researchers a numbers of themes emerged under which we report our findings and inform our discussions.

4. Findings

4.1 Crafting

The aim of the informal craft sessions were to build trust with residents, families and staff; getting to know the needs, likes and dislikes of residents whilst crafting. Residents created soft textile artefacts on a drop in and out basis, experimenting with a range of different coloured, textured and patterned materials (Figure 4). We visited frequently and demonstrated the value of residents' participation by giving personalised thank you cards for taking part and supported them in 'exhibiting' their creations informally in the care homes.

Sorting through the materials with residents articulating their choices allowed the researchers an understanding of their preferences in terms of aesthetics and tactility. During these activities, residents were also prompted to share more detailed stories about their lives; one resident shared with us, her experience of working in a textile factory making clothing upon finding materials similar to the colours of felt she had worked with. Discussing everything from where they grew up, family, travel, work and hobbies, this kind of rich information gave us an understanding of residents' life stories and informs us, as designers, of the wider issues pertaining to their design choices.

Figure 4. Residents experimented with combinations of textiles and accessories to create their designs.

As well as encouraging storytelling, these activities can inspire new connections and conversations as one carer commented that, 'it is exciting to observe the various benefits that design and craft activities can have for this population' as two residents worked together having not spoken before. Furthermore, an informal Christmas crafting event hosted by the researchers to engage new residents with the project saw participants create soft decorations or Christmas cards around a table in the main lounge. This collaborative activity encouraged residents to be 'hands on' with making their design choices and to comment upon and encourage one another's design direction (Figure 5).

Figure 5. Residents create and discuss Christmas decorations and cards.

4.2 Co-designing wearables

The rapport created during the crafting session encouraged residents' to be open about discussing the technology our team planned to use to track physical activity and location, which was a Samsung Galaxy S3 mini phone. Most residents pointed out that they do not carry wallets or handbags and in certain cases for the women, they may wear garments that do not have pockets. All the residents were also not keen on the size and weight of the phone. After explaining our project through the pictorial booklet we designed, ten residents expressed an interest in the project and participated further in the co-design workshops. During the co-design workshops we chatted, created and critiqued possible wearable design solutions that would hold the device and fit with their existing garments and lifestyle during and after the study.

The residents' design journeys were given context through the use of the various bespoke design tools. Residents made quick and decisive choices about their preferences for potential future wearables by sorting through the pictorial cards (Figure 6). The task is familiar and game-like, as residents build collections of cards to communicate the styles they like and dislike. Using the activity sheets, residents described their lives by detailing hobbies, likes, dislikes and their personal taste (Figure 7). Capturing this information on paper enabled residents to hone into specific themes for exploration within their design process. For example, one resident who shared stories about her career as a dancer and teacher took inspiration from the colours, patterns and textures of the dance costumes she had worn in her younger years (Figure 8). The personalised mood boards – which featured drawings, photographs, patterns, colours and motifs that are representative of the topics of interest that residents have shared - were useful tools in providing residents with a visual snap shot of their design development and in prompting and focusing conversation as residents 'see' part of themselves and their experience of the design process in the mood board.

Figure 6. Residents sort cards from the wearables card deck as inspiration.

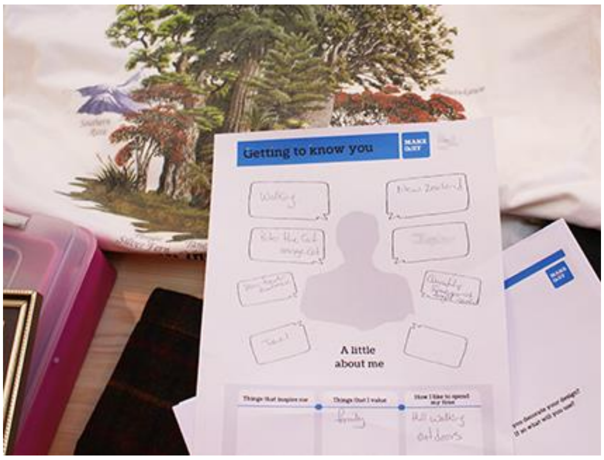

Figure 7. Simple worksheets are used to gather information and inspirations unobtrusively.

Figure 8. Personalised mood boards define design direction and inform the aesthetic of residents' wearable designs.

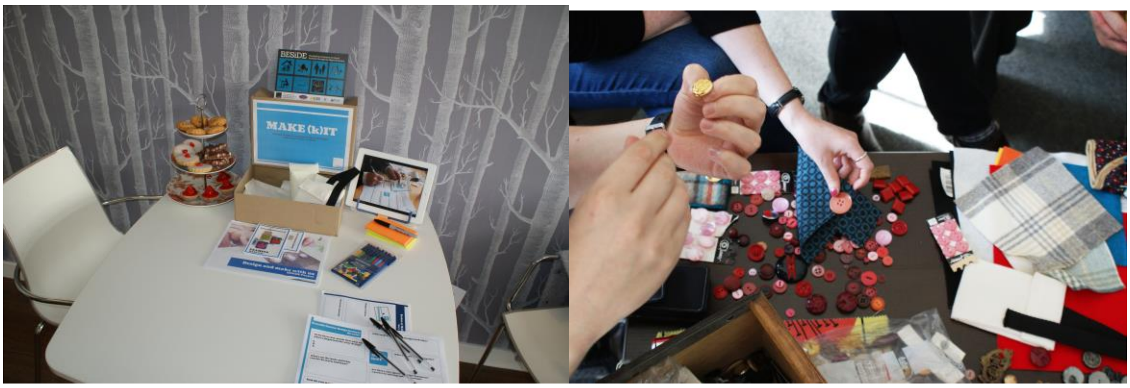

Figure 9. Make-(K)It and materials

These tools, which we eventually collated into a 'make-kit' (Figure 9), is useful in building a picture of individual residents' likes, influences and inspirations, which eventually contribute to the appearance, 'feel' and function of their designs. These tools are used responsively as and when they are needed by the researchers to support the participating residents as they move through each stage of design development. The activities resulted in the creation of personalised soft carrier prototypes that could be further customised or manipulated to illustrate and explore 'ways to wear'.

4.3 Participant Feedback

After completion of the activities and participants given the carriers, we visited the participants and staff for a feedback session. Feedback was gathered using a combination of informal interviews and feedback sheets. Of the ten residents who participated in the co-design workshops, five residents (2 male and 3 female) and 2 staff members (activity coordinator and care home manager) took part in the feedback. As for the other five who did not participate, one resident was hospitalised and the other four were feeling poorly. In general the feedback were positive as one participant remarked: "*I enjoyed the craft activities, the board that was made for me showing the time I was working in Timex and the area I lived in especially visiting the dancing hall, I hung up in my room. I enjoyed being able to suggest ideas, the Hilltown clock tower on the badge I liked that", (P05).* For some it is more about the company: "*I really enjoyed both of you coming in, for making my day, especially the Forfar Bridie", (P01).* Both staff members commented that the residents enjoyed the activities and the company. The home manager added that she would be looking to introduce and incorporate arts and craft in the resident's weekly activities.

5. Discussion

5.1 Craft: Enabling and facilitating understanding and agency

While expressing their creativity during craft activities, participants often related stories, giving the researchers insight into the context of their creations. Indeed engaging residents in craft and shared making activity can create open spaces for non-linear conversation and storytelling which in turn provide rich insights that can inform the design of prototypes and anticipate future scenarios of use. One resident, whilst sorting through a set of tartan swatches, told of his time in the Royal Navy and happening upon his regiment's tartan, he expressed that he would feel a great sense of pride to wear his tartan again (Figure 10). This resident understood that he himself may not benefit directly from any resulting changes to the care home environment as a result of the data gathered from the activity logging devices but told us that he would like to participate in support of future care home residents and if he could do so by also fashioning a wearable harking back to his time in the RN with his regiment then he would be pleased to do so. He also added that: *"It would give me an excuse to tell stories from that time in my life" (P03).* This understanding enables designers to comprehend more acutely the issues, needs and concerns of users regarding the role of wearable technologies that the project hope to introduce into their lives. For the participant it was more about identity and connecting with others and using the wearable as an opportunity to share about his life with others.

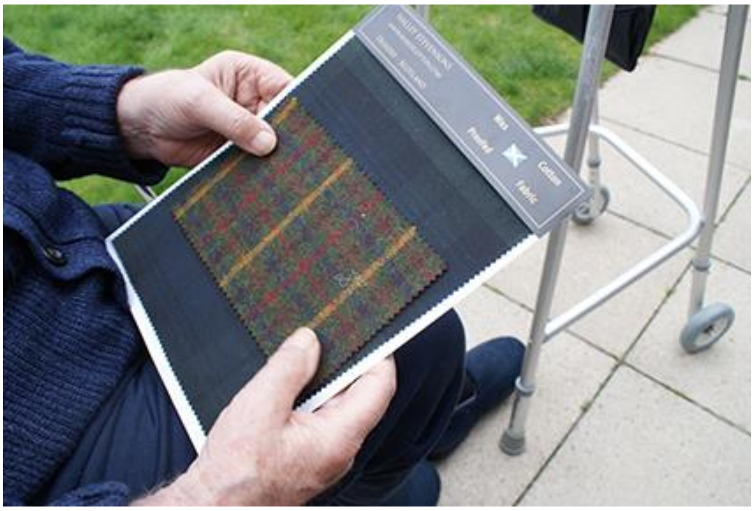

Figure 10. A resident reflects on his time in the Royal Navy in choosing his regiments' tartan for his design.

Engaging residents in a craft rather than technology focused process with soft and familiar materials – such as everyday fabrics, buttons and badges – was also useful in opening up discussion regarding technologies. This breaks down barriers for engagement for those who are not 'tech savvy'. When confronted with examples of current wearable tech, residents told us "I don't need gadgets" *(P04)* or "I would have to learn how to use it first" *(P09)*. In contrast, by creating personalised pouches or carriers which first describe visually an aspect of the wearer – their personality, skills or likes – and secondarily hold sensors, residents were able to design objects that would easily fit around their lives and everyday routines, breaking down some barriers to their perceptions of technology. This process also encouraged their confidence in asking questions and imagining how technology might be apply to their home environment.

Using this crafting approach together with the design tools that acted as visual prompts, allowed a range of insights and latent needs to be revealed that may not have been uncovered otherwise. The participants, with some support, were quite quickly able to define initial design requirements to suit their unique needs in terms of fit, comfort, style, acceptability and expectation. The residents displayed the mood boards and prototypes we created for them in their rooms and they were keen to show them off to each other as well as staff and family members.

Though these tools and materials were designed and chosen specifically to engage with and inspire residents in creating personalised wearables, their true value and potential was not observed until the live making sessions; First, the card deck set the scene for the research, inviting participants to question, discuss and ideate around the topic of wearables; Secondly, the activity sheets drew out personal experiences or potential influences to inform the design narrative in their own wearables; Finally, the textiles, craft materials and collaged mood boards engaged residents in the aesthetics and tactility of their design and gave form to their wearable. In using these tools at these specific junctures within the design timeline, residents were able to co-design crafted wearables in response to their own personal taste and practical needs.

5.2 Empathy, Mutuality & Reciprocity: Building Trust

Key to the development of positive relationships between the researchers, residents, staff and visitors is empathy and mutuality. According to Wright and McCarthy (2008) three qualities needed for empathic design are (i) a quality relationship between the designer and user to allow the designer to be attuned to the user's needs; (ii) a sympathetic disposition towards the other person; and (iii) an attention to the affective and emotional quality of their experiences. Through our craft and co-design approach, we developed a good relationship with our participants and were responsive to their needs and experiences. Residents need relationship reciprocity (Dee and Hanson 2014) to establish trust before imparting their knowledge and personal stories. We invested time to better understand their experiences starting from the initial introduction stage by chatting over a cup of tea and participating in in-house activities such as bowls with them. By immersing ourselves in their hobbies, daily activities and conversations, we gained residents' confidence and developed rapport. This in turn encouraged their interest and assurance in the design activities. It is also important to acknowledge that trust allows participants to feel comfortable in speaking their mind about what they want and not be overly positive or swayed by a designer's suggestion.

One interesting contradiction in this project is between the inclusion of and crafting with participants, and the actual activity monitoring purpose of the final design. On one hand we encourage personalisation, agency and empowerment via co-design but on the other hand the end product (i.e. monitoring device) is not facilitating any of this. We were honest with the residents, letting them know what the project was about from the onset. We explained to them the aim of the project and it is for the future betterment of care homes. Although those who agreed to participate did so out of altruism, it is important that we treat our participants with dignity, and one in which the device they would eventually carry should not stigmatize them. We acknowledged the diversity of capabilities and needs of the residents and that the solution needs to fit into the person's lifestyle and as such adopted an approach where empathy and mutuality is valued.

5.3 Flexibility and being responsive to residents needs

Care homes are busy environments prone to change and there are constant distractions caused by other activities such as daily tasks, housekeeping, visitors that may hamper research activity. It is essential to be flexible and agile in our approach whilst working in changeable settings such as this. Participants may have 'good days' and bad as well as being subject to surprise visits from friends and family; researchers must be respectful and responsive to these situations, gauging opportune moments for creation and design, or indeed appreciate when to press pause and resume the research activity at a more appropriate time.

6. Conclusion and future work

We introduced and showed how using a craft-based co-design approach helps to engage older people who may not be open to new technologies such as wearable devices. This is important especially when older people who belong to a different generation might not see technological devices as part of their everyday accoutrement. Shifting the focus from technology to craft can break down barriers for engagement for those who are not 'tech savvy'. Through craft, we were able to draw out residents' stories and concerns over shared activity. The group making activities also created a relaxed atmosphere, encouraging conversation to flow in a non-linear, open way from which rich insights can then be made to inform the design of wearbles. We revealed that crafting uncovered not only material preferences but also enabled creativity and increased confidence, agency and connectedness for participants. To develop a successful co-design session we recommend the building of trust, mutuality and reciprocity. This allows the building of relationships and partnership allowing participants to be open and feel assured of their feedback. However empathy, trust, mutuality and reciprocity does not happen instantaneously and requires an investment of time and effort. We also highlighted the need to be flexible, respectful and responsive when working in the context of care homes where activities may not always go according to plan. To develop acceptable wearables that care home residents would want to wear beyond research or buy for themselves because they find it genuinely useful, the needs, experience and desires of these potential users need to be considered. As such, a bespoke and intensive approach is expected mainly because of the demographic we are designing with experiences some form of physical or cognitive deterioration and this requires time, sensitivity and flexibility build into the design process.

With research involving people and the gathering of data, there is generally a focus on pre-built, ready to wear wearable devices. The user or participant of a study is usually given the device, and participants - if they agree to the study - just have to 'get on with it' (unless they withdraw from the study). Our co-design and craft approach and 'make-kit' may prove useful in future research activity with care home residents where personalisation of technology is involved. Although negative about the attributes of the device initially, the residents who co-designed with us reframed their view where the wearable through craft, became a reflection of their identity, personality and preferences and also potentially act as a conversation starter. By allowing older adults to have a voice in the process, this might lead to better adoption and adherence rate not just for a research study where the outcome might not benefit the users immediately but for any telecare or healthcare devices used at home or in social care. With the rise of the DIY and maker movement, users in the future could either work with designers and/or technologist, or by themselves be provided with options or a kit to personalise their own health technologies.

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To Shed Some Light on Empowerment: Towards Designing for Embodied Functionality

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Abstract: We present a case study as part of an investigation into the value of *Embodied theory* for the design of mixed physical-digital interactive products. An interactive light system was designed that *empowers* an independent living person with an Autistic Spectrum Disorder (ASD) in managing domestic activities. Reflecting on the case we develop our vision of *Embodied Functionality* (EF). Designing for EF goes beyond 'distributing' information technology in the environment. It aims at creating interactive physical-digital products that play a functional role (i.e. become part of) a person's embodied being-in-the-world, involving a person's identity. It does so by utilizing existing structure and by supporting action-perception couplings, reflection in- and on action and autonomy in social coordination. EF opens up an alternative design space holding the promise of a more successful appropriation of interactive (assistive) products into people's everyday lives.

Keywords: Embodiment, Empowerment, Interaction Design, Situated Practice

1. Introduction

In this paper we explore the possible functional roles of interactive products within people's embodied practices by reflecting on a case of designing an assistive device for a person with Autistic Spectrum Disorder (ASD). The study is part of an ongoing investigation into the value of *Embodied theory* for designing interactive, mixed physical-digital systems (Van Dijk & Van der Lugt 2013; Van Dijk et al, 2013; Van Dijk et al, 2014; Van Dijk & Mitchell, 2014; Van Dijk & Hummels, 2015; Hummels & Van Dijk, 2015). 'Embodied theory' we use here as an umbrella term for a variety of notions that all share a basic commitment to the idea that the human body is essential to understanding the way people make sense of- and are able to act in- the world. It takes as a starting point the subtle interplay between brain, body and world (Clark, 1997), emphasizing how people are always already 'caught up' in the world as active, embodied beings. Consequently, people make sense of the world through skilful, situated interactions (Dreyfus, 2002). In our work we draw from phenomenology (Merleau-Ponty, 1962; Heidegger, 2013; Dreyfus, 1990) Situated Cognition (Suchman, 2007; Clancey, 1997; Lave, 1988; Rogoff & Lave, 1984; Goodwin, 2000), Embodied- and Distributed Cognition (Clark, 1997; Hutchins, 1995; Kirsh, 2010) and theories on action-perception coupling and skill (Dreyfus, 2000; Ryle, 1949; Gibson, 1979, cf. Van Dijk et al, 2014, for an overview). Our interest is in finding out how mixed physical-digital products and systems may actively contribute to, i.e. become part of, a person's *embodied being-in-the-world* (Van Dijk & Mitchell, 2014).

Embodiment beyond distributed cognition

One line of thought within Embodied theory that is popular with interaction designers is *distributed cognition* (Van Dijk, et al, 2014; Clark, 1997; Hutchins, 1995). Much of this work centres on reducing cognitive load in problem solving, by using physical objects to externally represent problems and compute solutions (Kirsh, 2010; Clark, 1997; Norman, 2002). Related theories call specific attention to the role of the *social context*, explaining how people collaboratively make sense of things, using concrete artefacts as binding elements (Bentley et al, 1992; Dourish, 2001; Luff et al, 2013). Hollan et al (2000) summarize: "[c]ognitive processes may be distributed across the members of a social group [and c]ognitive processes may involve … external (material or environmental) structure." (Hollan et al, 2000, p. 176). Principles of distributed cognition are at play in a variety of new interface forms 'beyond the desktop', such as: *tangible interaction* (Ishii, 2008), *multi-touch platforms* (Fischer et al, 2000) and *ubiquitous computing* (Weiser, 1991; Abowd and Mynatt, 2000).

We have suggested elsewhere (Van Dijk et al, 2013; Van Dijk et al, 2014) that this line of work represents a quite modest application of Embodied theory to interaction design. Taking a phenomenology-inspired view, designing products that fully acknowledge and support our *embodied being-in-the-world* would suggest something more than distributing digital information into the physical- and social environment (See also Hummels & Levy, 2013; Djajadiningrat et al, 2004; Robertson, 2002; Svanæs, 2013). Perhaps the question of how to design *an interface* to an information device already leads us astray, as it interprets the challenge as how to design an 'embodied interface' to pre-existing digital functionalities, instead of asking how the *function* of the device can be part of our 'embodiment' as such. Perhaps, then, we should ask how to design an interactive product (both physical form and interactive behaviour, which may include digital information processing) that becomes, in its totality, a meaningful element in a person's embodied practice. Theoretically, this means moving away from the focus on how to represent *information*. In its place we a potential design space opens up that highlights such aspects as the *situatedness* of human *practices* (Suchman; 2007; Lave, 1988; Dourish, 2001), *action-perception couplings* (Stienstra et al, 2011) and *learning-by-doing* (Klemmer et al, 2006; Schön, 1983). Our aim is precisely this: to design interactive artefacts that support people, as *embodied copers* (Dreyfus, 1990) in developing a *grip* on the world through their on-going, skilful interactions with it (Klemmer et al, 2006; Van Dijk and Mitchell, 2014).

In what follows, we further elaborate these themes using a case of designing an assistive device for a person with ASD. We reflect on the way in which concrete decisions in the design relate to the possible functional role of the system within this person's everyday practices. We first present our case study and its final design, an interactive light system supporting self-management of daily structure. We then present key design issues and observations that surfaced over the course of three iterations. For each issue we describe how it scaffolded our theoretical reflection, which in turn gradually sharpened our insights regarding the overall aim as mentioned above. We draw partial insights together in a discussion section in which we introduce the concept of Embodied Functionality (EF). The promise is that this concept may open up an alternative design space that goes beyond distributed information processing, incorporating a stronger concept of embodiment. Concerning the design of assistive technologies for people with special needs (Gitlin, 1995; Carmien et al, 2008; Ojasalo, 2010) we speculate that the concept of EF may help to create products that are less likely to be *abandoned* in practice (Philips and Zhao, 1993) and be incorporated by people supporting autonomy in everyday life. More generally we speculate that designs based on EF may contribute positively to the overall goal of a human-centred design, helping to ensure that products fit in well with the embodied practices of their users.

2. Case study: interactive technological support for a person with autism

In a participatory design project (Sanders & Stappers, 2008) starting mid 2014, lasting one year, we designed for- and with one client, Max (not his real name, male, age 31, above average intelligence), with Asperger's syndrome (Bryson et al, 1997). We give a short impression of Max's situation before describing the design process. Max lives independently and by himself in fully equipped apartment in a *supported living facility* in a regular neighbourhood in a medium-sized city. His flat opens to an internal hallway where other clients with comparable needs are his neighbours. Max has a part-time job in a warehouse and he regularly cooks and eats with the people in his hallway in a central kitchen-living room. Max has three main professional caretakers (though the exact number varies), one of which is always available to the clients to offer assistance, occupying a control unit at the end of the hallway, during the day. His caretakers take turns in a daily 30-minute talk with Max about his daily affairs. Following recent developments in health-care policy, the organization that offers Max supported living services was interested in new technologies that could *empower* their inhabitants in living an independent life.

A known challenge for people like Max concerns executive functioning (Bryson et al, 1997), leading to impaired working memory and planning of tasks and inhibition of impulses. Compulsive and ritualistic behaviour may occur as well. As a result, mundane household- and administrative tasks become a challenge. External triggers easily distract Max. He is drawn towards 'irrelevant' details or caught by worries and fears, to the extent that the task as a whole is never finished. This may especially be challenging on a day off, when the structure of the day is less predictable and when Max is free to do what he wants, instead of receiving explicit work instructions. We decided to focus helping Max to remember, focus on and accomplish self-intended domestic activities (household, social, leisure, or otherwise).

Three main design iterations each resulted in a physical prototype and always included:

1) Refining the design challenge based on new insights
2) Exploring design opportunities building on previous iterations together with Max
3) Integrating ideas into viable concepts
4) Elaborating the most promising concept into an *experienceable* prototype
5) Evaluating prototypes with Max and caretakers in the actual context-of-use.

Interaction with Max included casual conversation, three longer interviews, collaborative acting out of Max's activities and collaborative reflection on various prototypes in his apartment, telephone conversation, email and chat. We also had interviews with two of the main caretakers, as well as with the manager of the facility, and with Max's nearest neighbour, also a person with Asperger's syndrome. The process moved progressively out of the studio into the actual use context (Hartswood et al, 2008). Once the second prototype was finished it remained at Max's home, to be picked up only when needed.

We took a Research-through-Design approach in the spirit of Overbeeke et al (2006). We use the iterative structure of a concrete design project to progressively weave together 1) ethnographical and collaborative insights into the user practice (Hartswood et al, 2008; Blomberg & Karasti, 2012) 2) design insights concerning form and behaviour of the product, and 3) theoretical insight regarding Embodied theory (and its implications for design).

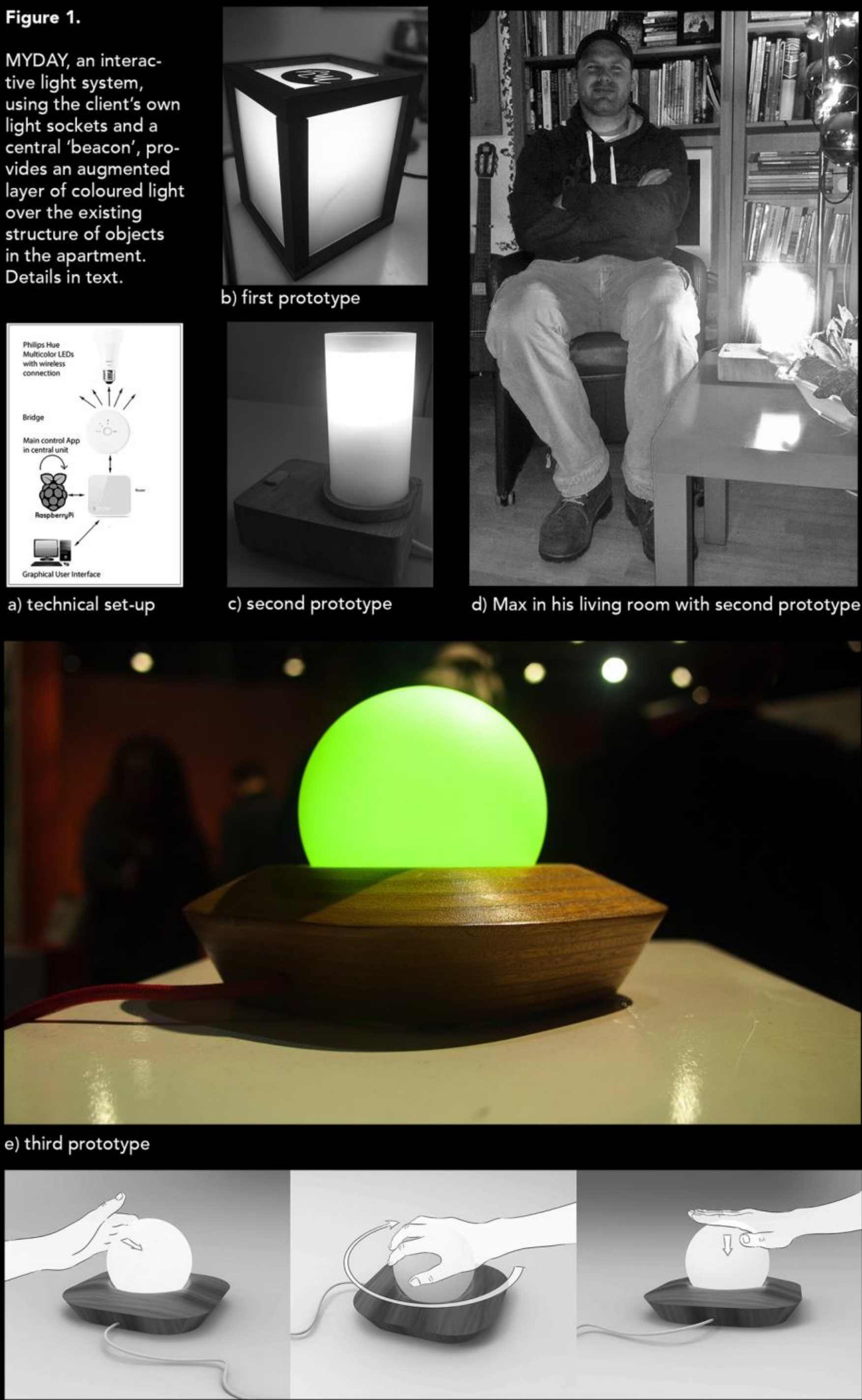
This means our understanding of Max's life, the design of the product and our understanding of the Embodied function of the artefact developed hand in hand, with each influencing the other along the way. Our approach is deliberately an in depth case for one client, investigating the historically and contextually developed details of an individual person's life-world (Agre & Horswill, 1997; Brereton, 2013) and the potential supportive role of an interactive artefact in it. Our theoretical analysis however uses the case study insights to analyse the role of interactive products in embodied practices in a more general sense. (Hartswood et al, 2008; Blomberg & Karasti, 2012).

3. MYDAY

In this section we describe the final design. MYDAY is a ubiquitous, interactive light system that helps clients like Max in structuring daily activities (Figure 1). Technically it consists of a set of wireless, multicolour light bulbs (*Philips Hue*; Figure 1.a) placed in conventional lamp-bodies, plus a central station we call the beacon (Figure 1.b, 1.c and 1.e).

Figure 1.

MYDAY, an interactive light system, using the client's own light sockets and a central 'beacon', provides an augmented layer of coloured light over the existing structure of objects in the apartment. Details in text.



a) technical set-up

b) first prototype

c) second prototype

d) Max in his living room with second prototype

e) third prototype

f) tangible interaction design: slapping the bowl skips a task, grinding the bowl in a circular motion deletes a task, and pressing the bowl for several seconds declares a task finished.

Using MYDAY, Max plans a number of self-chosen activities, e.g. 'doing the dishes' or 'administration' via a conventional online calendar (*Google*) on his PC. Max assigns to each activity a time-window, a location in his apartment and a colour. The calendar communicates wirelessly with the beacon and light bulbs via an embedded Raspberry Pi server (Figure 1.a). When an activity is due, both the beacon and the lamp in the associated location light up in the selected colour, for the set time-window. This cues Max to start the associated task. Once the time is up, the next activity will 'light up' in the same way. Each activity thus has its own dedicated physical location, as seen fit in advance.
The second prototype (Figure 1.c) allowed three real-time user inputs on the beacon, by pressing a button once, twice or three times, in order to *skip* an activity, *postpone* an activity, or declare an activity *finished*. In the third prototype (Figure 1.e) we designed tangible interactions to replace the buttons (Figure 1.f).

4. Insights from reflecting on the design case

In this section we discuss five insights that grew out of concrete design considerations during the iterations, in relation to our growing understanding of Max's habits and routines, and relevant aspects of Embodied theory. These insights together build up to form our notion of Embodied Functionality, which we present in the discussion section that follows.

1. Highlighting the existing action-affording structure in the environment

Early on we explored with Max some ideas on sending reminders via a smart-watch. Max dismissed the smart-watch, saying it would distract him. He did not want 'yet another thing' to 'attend to', next to 'all the things he already needed to attend to'. He made a point of wanting to 'have his hands free'. We started thinking about a system that would completely blend in with Max's existing 'lifeworld' (Agre & Horswill, 1997). We observed that his apartment contains many objects, in various arrangements, in boxes, bags, stacked on tables, cubboards, chairs, and on his ironingboard (Figure 2.). These familiar, 'habituated objects' (Brereton, 2013) are meaningfully coupled to Max's habits and routines. Yet given a specific task, the abundance of 'stuff' also creates distraction. People with ASD have difficulty attuning to larger wholes, and may be overwhelmed by large amounts of seemingly unrelated stimuli (Bryson et al, 1997). We observed Max initiating one activity, then half-way through being drawn to a certain object (a 'trigger', in the words of his caretaker), inviting Max to start a new activity, leaving the first unfinished. With interactive light, we decided to 'highlight' the relevant aspects of the apartment to the task at hand, while no extra effort would be needed of Max in order to interact with a separate system of reminders. MYDAY helps Max to focus on the relevant cues for action that the personal arrangements of things in his apartment already offer (Hutchins, 1995; Agre & Horswill, 1997); a design concept quite unlike a tangible or wearable device offering 'reminders and notifications'. This was our first step towards developing the concept of 'embodied functionality'.

Figure 2: Max's lifeworld structure, with the ironingboard as an organizational platform.

2. Supporting task-relevant action-perception couplings

In trying to 'empower' clients in leading an independent life, many assistive systems have been proposed that provide the user with useful instructions on what to do (Gitlin, 1995; Carmien et al, 2008; Ojasalo, 2010). On the negative side, explicit instructions may actually make the receiver *less empowered* (Gitlin, 1995). In this regard, Max showed explicit aversion towards the planning schedules pinned on his corkboard (Figure 3). Max: 'I know they are useful, but it feels like they take away my freedom'. We wanted to retain Max's sense of freedom. We realized Max is actually not in need of *instructions*. He knows what he wants to do. His problem concerns *staying on track* while he is doing it. This is why the coloured light does not *say* what the task is, only that 'a task' should start 'about now', 'over there'. In Suchman's terms, MYDAY transforms the *plans* (in the calendar) into dynamic cues that invite *situated actions* (Suchman, 2007). It does not *prescribe* action: what Max does emerges from his interactions and is not derived from following instructions a system provides. The light taps into what Dreyfus calls 'absorbed coping' (Dreyfus, 1990) the largely unconscious mode of interaction driven by affordances in the environment (Gibson, 1979). It takes part in action-perception couplings (Van Dijk et al, 2014) by drawing visual attention to relevant elements in the environment, what Goodwin calls, interestingly, 'highlighting for perception' (Goodwin, 1994).

3. Planning as reflection-on-action leading to adaptation of habits and space.

In MYDAY Max plans his activities using a calendar. As said, in embodied routines, plans are artefacts that *reorient* embodied actions, rather than *prescribing* them (Suchman, 2002):

"As projective and retrospective *accounts of* action, plans are themselves located in the larger context of some on-going practical activity. (Suchman, 2007, p. 69)"

We realized that the *activity of* planning the calendar is not only an interface operation in order to put plans in the digital system. It is also an opportunity to *reflect on* past events, in

Schön's sense of reflection-on-action (Schön, 1984, see also Van Dijk et al, 2011). In this light we envisioned a scenario in which planning the calendar would be part of the daily meeting of Max with his caretaker. Planning the next day is explicitly a moment of stepping back from the on-going flow of action, a moment to look at your own activities from a distance. With some help of the caretaker, the new lighting plan incorporates 'lessons learned' from before.

Planning activities with MYDAY may not only change Max's understanding of his own behaviour, it may also literally change the physical organisation of the space. Presently, Max's room is cluttered with objects. As Max keeps being distracted in the midst of an activity, abandonment his projects *produces* an even more disorderly configuration of stuff which results in even more distracting triggers, creating a dysfunctional feedback loop in which chaos creates more chaos. His caretakers often instruct him to tidy up and put everything 'in its proper place', but Max feels this as belittling, and even if he accepts it in theory, it is hard to stick to in practice. The idea of MYDAY is to allocate activities to locations. This means Max is prompted to think about what tasks should go 'where', close to one of his lamps. Our idea is will lead him to gradually reorganize objects and lamps so as to make more effective use of the system. When the project was halfway through, Max indeed started to talk about his apartment *in terms* of sections divided by the lamps:

> "On this side of the room" {makes a cut with his hand in the air, then points to the window} "is where I have talks with my caretaker {pause} by *that* lamp {points to a lamp at the window}, while on *this* side {gestures towards kitchen table} is where I fold my laundry, under *this* lamp {points at the table lamp}"

This suggests, we speculate, that Max started to reconfigure his own perception of the space in terms of spatially organized *workspaces,* each reserved for certain tasks, a characteristic of properly functioning *lifeworlds* (Agre and Horswill, 1997). That is, in using the system, Max's space may become gradually transformed into more effective configurations, without the feeling of being forced to give up on "ones' own preferred ways of doing" (Gitlin, 1995).

4. Tangible interaction affording reflection-in-action

Once we saw the 'offline' planning activity as an instance of reflection *on* action, we explored possibilities of reflection 'in action' (Schön, 1983). This we kept in mind when designing a set of tangible interactions on the beacon. By pressing the bowl, Max is prompted to take a moment to acknowledge the fact that indeed he has successfully finished a task: something to celebrate. Likewise, the 'grinding motion' to delete a task makes Max is conscious of taking responsibility for the consequences of deciding not to do something he had planned. The interaction thus invites reflection-in-action, what we called a 'micro-moment of reflection' (Van Dijk et al, 2011). Note that tangible interaction design is used here *not* as providing an 'intuitive' or 'easy' interface to digital information. The tangible interactions of prototype 3 have little information value over and above the basic button in prototype 2 (Figure 1.c). Instead, we used tangible forms to invite the embodied action that goes along with reflection-in-action, which is needed for developing a skill in dealing with comparable situations (Klemmer et al, 2006; Dreyfus, 2002).

5. Supporting autonomy in social coordination

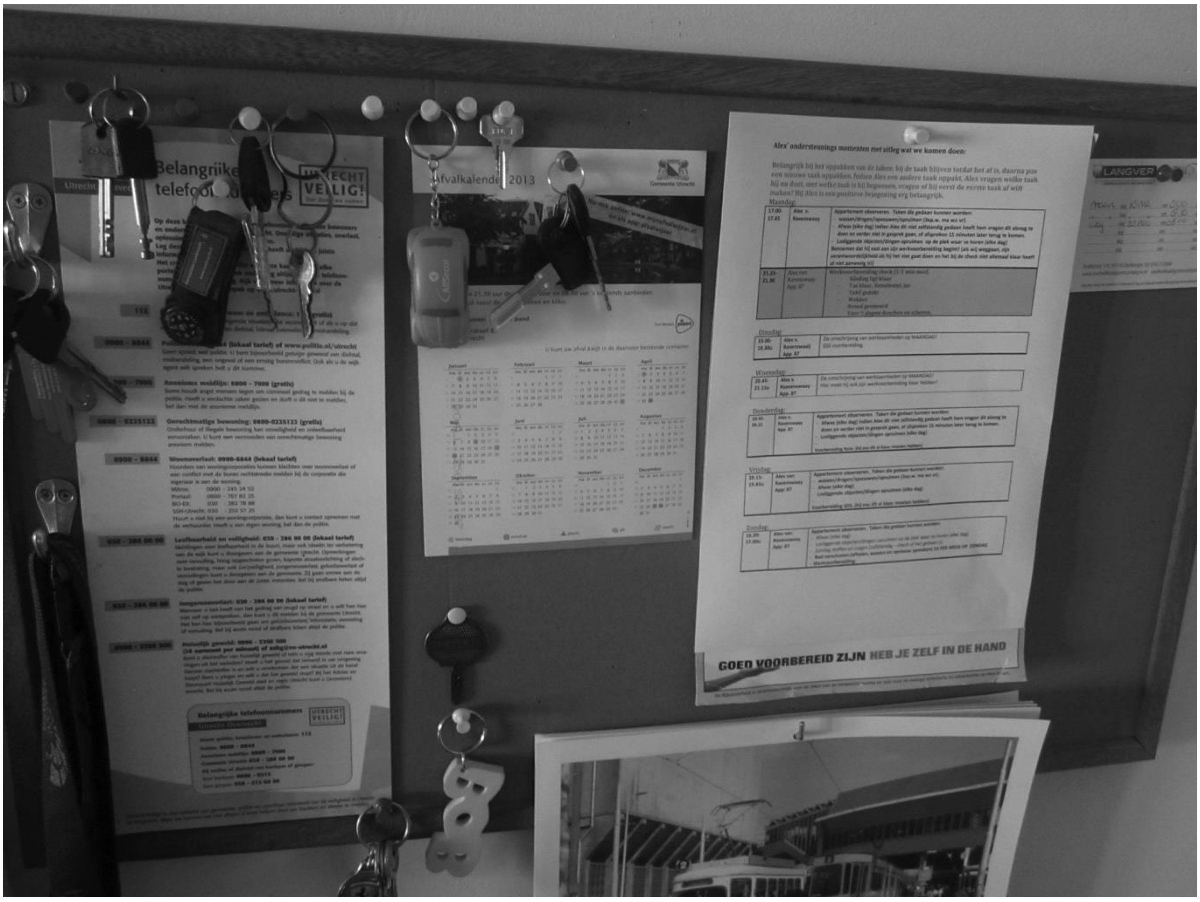


Figure 3. Planning schedule created and pinned to the corkboard by the caretaker (right side).

Situated Cognition explains how artefacts mediate social relations (Brereton, 2013, Lave, 1988; Suchman, 2007). During the project we came to see how MYDAY mediated Max's sense of autonomy in relation to his caretakers. MYDAY supports Max to live life his own way, rather than technology imposing on him externally defined methods. The lamp highlights *his* configuration of objects in the space, configurations that are meaningful to Max. Max programs the lamp. He puts *his plans* into the system. The cues are essentially 'notes to self', not instructions by his caretakers. During the project, 'the lamp' helped Max him take a (more) autonomous role in negotiations with his caretakers. For example, at some point Max began to explicitly contrast 'his lamp' (see Figure 1.d) with the planning schedule mentioned earlier (Figure 3.) Max told us on various occasions how one caretaker had heard about the 'lamp project', expressed her enthusiasm, and promptly proposed to 'put all the tasks of the schedule into the lamp'. For Max, this was out of the question: "I said to her, wait a minute, not so fast, we are not going to put *your* schedule into *my* lamp". This illustrates how artefacts not only contain information but also mediate social (power) relations (Suchman, 2007). Later on he added that perhaps it *would* be good to put the schedule into the lamp, because he knew it 'was good for him', yet he continued to have issues with the idea. We concluded these social micropolitics should actually be an explicit function of the device. Programming the lamps could be one of the returning topics in the daily meeting with the caretaker. By focusing together on the practical question of how to 'program the lamps for the next day', a clash of opposing views might be avoided. The resulting configuration would be a compromise between Max and his caretaker. The lamps are not representative of one party (as the schedule was the caretaker's view on what's best for Max). Taken together, the lamps function to support *participatory sensemaking* involving Max and his caretaker (De Jaegher and Di Paolo, 2007; Van Dijk & Hummels, 2015; Hummels & Van Dijk, 2015).

5. Towards Embodied Functionality

We started out suggesting that designing for embodiment means more than designing for distributed cognition by means of tangible or wearable technologies (Van Dijk, et al, 2014). In this section we draw our insights together to discuss what this 'more' means, concretely.

Designing for Embodied Functionality

Phenomenological, action-oriented theories of embodiment (Merleau-Ponty, 1962, Dreyfus, 2002, Noe, 2004) first and foremost ask the question of how people *live* their world, rather than how they *represent* it. The starting observation is that people are always already *dealing with* the world, and how, in the course of that dealing, certain aspects of the world show up as meaningful. Ongoing parallel flows of perception and action lead to *couplings* that we may call embodied *skills* (Ryle, 1949; Dreyfus, 2002). Through such skilful coupling we attain 'grip' on the world (Merleau-Ponty, 1962). This is why we perceive the world first and foremost in terms of affordances for action (Gibson, 1979). Of interest to us in particular is the fact that artefacts are readily appropriated and taken up within such couplings, up to the extent that they can be seen as extensions of ourselves. In this regard, the phenomenologist Merleau-Ponty writes:

> "Sometimes, finally, the meaning aimed at cannot be achieved by the body's natural means; it must then build itself an instrument, and it projects thereby around itself a cultural world" (Merleau-Ponty, 1962, p. 169).

The 'cultural' referred to by Merleau-Ponty hints at another aspect of our embodiment. What ethnomethodology has understood quite well is that action-perception couplings emerge as always already *situated in a practice*, and practices are a social affair (Rogoff & Lave, 1984; Suchman; 2007). This entails that getting a grip on the world is a *participatory* achievement (De Jaegher & Di Paolo, 2007), something we do against a socially situated background, mediated by artefacts.

In all, the world we live, our lifeworld, which includes our designed tools and artefacts, is not the physical space surrounding our physical body, but rather what is called the *enacted world* (Varela et al, 2001) that we skilfully and socially sustain. Agre & Horswill (1997), drawing on Schutz (1967), define the lifeworld as "an environment described in terms of the customary ways of structuring the activities that take place within it … maintained by conventional uses of tools and materials” (Agre & Horswil, 1997, p. 118).

We sought to design interactive products that, both in function as well as in form, play a meaningful role in sustaining a person's embodied couplings to the lifeworld. The design of MYDAY illustrates a number of possibilities to do so:

- Highlighting relevant aspects of the action-affording structure in the environment
- Supporting task-relevant action-perception couplings
- Supporting learning through reflection in- as well as on action
- Supporting autonomy in social coordination

Together, these principles make up what we call designing for *Embodied Functionality (EF).* EF is meant to reframe and give new direction to design. Taking the field of assistive technologies as an illustration, we give two examples of where EF may be used to reframe orthodox conceptions of designers. First, we currently see a proliferation of devices that essentially provide contextualized *instructions and notifications* to the user. Take for example pill-dispensers that notify the user to take a medicine (Gitlin, 1995; Ojasalo, 2010). The question is whether all these notifications and reminders really help clients in the actual, practical circumstances of everyday life. Likewise, wearable- and ubiquitous systems are increasingly used to gather large amounts of behavioural data and continuously *monitor* the client (Seppälä et al, 2014). Monitoring is certainly useful for researchers and therapists, but it is less clear how these Big Data can be meaningful in supporting how a person lives his own life and how s/he may experience autonomy. We believe that the notion of Embodied Functionality may be used to critically examine such questions and explore alternative kinds of products that take on a different role than do the majority of assistive devices today.

Further understanding of Embodied Functionality

In closing we comment on how this particular case study provided us with a fresh perspective on Embodied theory itself, which sharpened our insights in several ways.

First, the case invited us to be more explicit about the role of *learning*, i.e. adapting ones' routines and habits through experience. Schön's famous concepts of reflection in- and on action (Schön, 1983) seem to work quite well to describe how a person may temporarily step back from his activity, reflect, and gradually develop both his skills and routines as well as reorganize the objects and tools in his lifeworld to better fit those skills and routines.

Second, the goal of designing for *empowerment*, central to this case, brought insight into the way embodied interaction through interactive artefacts relates to a person's sense of *autonomy and self-control*, something that we had not analysed clearly before. This relation is not new to Embodied theory. Dreyfus (1991), Clancey (1997) and Lave (1988) all have discussed the relation between embodied action and ones' sense of self. Heidegger analysed how the hammer as 'equipment' relates to the identity of the carpenter within a community of practice (Heidegger, 2013). In this regard it is interesting that Riemer and Johnston (2014) claim much of todays' IT technology actually *lacks* the quality of *equipment*:

> "Use of equipment is at the heart of our human way of being, which is to be engaged in practices. Practices and equipment *are constitutive of self* … [I]ndividuals express their (professional) identities through the equipment they use. Replacing this equipment [with information technology] might in the worst case equate to tearing apart one's (professional) lifeworld, one's existence, which was built on the basis of what one does and therefore how (in what way) one 'is'" (Riemer & Johnston, 2014, p.10.)

That is, learning to, and being able to skilfully use equipment, as part of ones' being-in-the-world is a prerequisite for being an autonomous person. We believe EF may help to design interactive technologies that function as equipment – in other words, which help a person to be autonomous, and thereby, to be most fully himself. In the context of designing assistive technologies for people with special needs, such as Max in our case, we see empowerment as precisely as the degree to which one is able to "express [ones'] identity through the equipment [one] use[s]". Using the product should feel like 'something *I do* with the tool', rather than as 'something the tool does for me' or something 'the tool instructs me to do'.

6. Conclusion and future work

In a one-year participatory design process we explored how an embodied perspective would play out in designing a system for and with Max, an independently living person with ASD. By reflecting on the design and developing a growing insight into Max's lifeworld, we explored an alternative functional role of assistive technology in supporting embodied practices. We call this Embodied Functionality (EF), which means to guide a person towards the action-affording structure of a person's own environment, to sustain action-perception couplings, to enable reflection in-and on action, and to strengthen a person's autonomy within social coordination. In the context of assistive technologies we speculate that designing for EF can create products that will be more readily accepted and appropriated in embodied practices, and thereby less likely to be abandoned (Philips and Zhao, 1993). Currently we are developing a robust working prototype of MYDAY that can function for several weeks without technical assistance, to assess more deeply the actual ways in which the system comes to function as an aspect of Max's everyday life. Furthermore, we intend to explore possibilities of incorporating movement sensing and action monitoring, with the aim of investigating in a critical way how, from an Embodied Functionality perspective, these technological trends may add real value to a person's empowerment.

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Measuring Product-Related Stigma in Design

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Abstract: Many medical and assistive devices are experienced as unpleasant and uncomfortable. On top of their discomfort, product users may also experience social unease. We label this process "product-related stigma" (PRS).
This paper presents two measuring techniques that aim to objectively assess the 'degree' of PRS that is 'attached' to products. Both experiments focus on the behavioral deviations in the walking path of passers-by during a public and unprepared encounter with a user of a stigma-sensitive product (dust mask).
The 'Dyadic Distance Experiment' measures exact interpersonal distances, whereas the 'Stain Dilemma Experiment' presents the passer-by with a choice in his walking path.

Both experimental techniques are predominantly suited as comparison tools, able to compare products on their PRS-eliciting potential.
Designers and developers can use these results to justify design decisions with quantitative data, to assess which product properties have influenced certain reactions, and to what extent subsequent improvements have been successful.

Keywords: Product Semantics, Design for health, Design and Emotion, Inclusive Design

1. Introduction

Imagine that you are walking through the local shopping mall, wearing a dust mask. Apart from your own discomfort, you might also experience social unease in the people around you. As they approach, you might observe their anxiety, laughs, or frowns. As they pass, you might feel how they keep their distance from you. Reactions elicited by these unprepared encounters are at the basis of the research presented in this paper.

We label this phenomena product-related stigma (PRS). PRS considers stigma-charged interactions and conflicts between products, users, and bystanders within a specific cultural setting (in the example above for example, we refer to the Western culture). Due to the process of PRS, a user that was unconstrained by any stigma may engender stigmatic reactions because of the product he or she has to use, regardless of whether this usage is voluntarily or forced.

Stigma-sensitive products

Due to their appearance, and enforced by existing stereotypes, certain products can become burdened with stigma-sensitivity. Some stigma-sensitive products carry a long history of rejection while others become questionable or undesirable as soon as they move out of their intended context or culture. An invisible hearing aid or a prosthetic leg that is covered by clothing will not attract people's attention. As soon as it becomes visible to bystanders, the interaction changes. Hence, visibility is an important factor (Goffman, 1963; see also Jones et al. 1984, for a discussion of six dimensions of stigma). Our insights apply to those products that are visibly worn or used in close proximity to the human body, where they are perceived and evaluated by people in the immediate vicinity.

Products that can be linked to PRS include:

- Protective devices: all products that are intended to free us from discomforting or unsafe situations. (dust masks, hearing protectors, etc.).
- Assistive and medical devices: Products that assist or complement the human body and promote user independence in daily tasks (wheelchairs, crutches and prosthetics). Related, yet overlapping are the medical devices that are used for monitoring, treatment or revalidation.

In future research we would like to assess if our insights can be extended to all products that are semantically linked to the body. In the following decades much more technology-driven products will become a complement to our bodies. These products will not only stretch the boundaries of our capabilities, but they also give rise to new and unfamiliar body-near artifacts that may or may not be socially accepted and approved of (Google glass, Microsoft HoloLens, etc).

In both studies we used dust masks as stimuli. They attract visual attention, are semantically linked to the user, and are stigma-sensitive within our Western culture. We do acknowledge that dust masks have different cultural meaning depending on where they are used. Although often intriguing to the Western eye, protecting the face from polluted air, cold weather, sun or viruses is common behaviour in China and other Asian countries. In those cultures dust masks are an everyday product that serves a broad range of needs ranging from self-protection to health etiquette.

Behavioral reactions of bystanders and passers-by

Once bystanders have perceived and appraised the user and his or her stigma sensitive product, they have several ways in which they can respond and behave. Bystanders often demonstrate mixed appraisals and responses. Although people may feel some revulsion to a user of a prosthetic arm, their actual behavior may reflect sympathy and kindness. In order to explain such findings, social psychologists have proposed a variety of dual process models

(Gawronski and Bodenhausen, 2006; Pryor et al., 1999; Smith & De Coster, 2000; Strack & Deutsch, 2004).

As the basis for our experimental explorations we opted for the dual process model as proposed by Pryor et al. (2004). Pryor indicated that there is an important reflex reaction within the first second, possibly followed by a more deliberate reaction that takes its time to build up.

A thorough assessment of the behavioral reactions of bystanders implies a study of the initial confrontation as well as the more deliberate and thoughtful responses that follow.

We initiated our explorations in Italy with a study of the avoidance-related reflex reactions of bystanders to dust masks. The 'Approach and Avoidance experiment' (Vaes, 2010) was set in a lab environment and captured reflex reactions to pictures of people with and without dust masks, presented on a screen.

During the experimental explorations that followed, we shifted our focus away from the lab and towards the real-life encounter between dust mask users and bystanders. In our attempt to approach and observe the real phenomenon we quantified the PRS-potential of products by studying the behavioral reactions of bystanders during a public and unprepared encounter with users of stigma-eliciting products. This unprepared encounter proved to be a good instance for measuring behavior, because passers-by are unable to 'mask' their reactions in these instances. We gradually progressed towards the parameter of interpersonal distance as a promising measure, more specifically, the moment in which the passer-by passes our product user. By averaging the behavioral reactions of a large sample of random passers-by varying in age, gender and ethnicity, we were able to obtain a more objective measure.

Interpersonal dissociation (social distance) and avoidance

A defining and immediate reaction to stigma seems to be avoidance. Measuring interpersonal or social distance is a common method used to examine stigma and it refers to people's willingness to avoid versus interact with individuals (LeBel, 2008). Previous explorations clearly indicated that the presence of a stigma-eliciting dust mask affects the interpersonal distance between the passer-by and the research partner. (Vaes, 2012)

Hall (1966) states that the social distance between people is reliably correlated with physical distance, as are intimate and personal distance, according to the following delineations: intimate distance for embracing, touching or whispering (15 to 46 cm), personal distance for interactions among good friends or family members (46 to 120 cm), social distance for interactions among acquaintances (120cm to 370cm), and finally the public distance used for public speaking (370 cm or more) (figure 1).

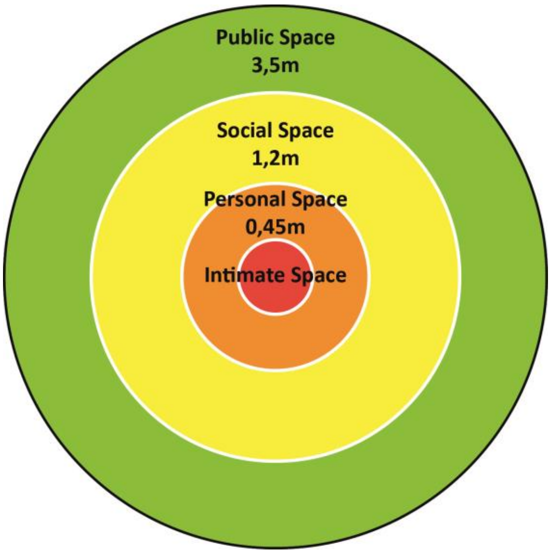

Figure 1. Correlation between social distance and physical distance between people (Hall, 1966).

Hall (1966) also noted that different cultures maintain different standards of personal space. He separated cultures into two basic categories: contact and non-contact. In contact cultures, physical touching between acquaintances is permitted and even necessary for establishing interpersonal relationships. Such cultures include Arab, Italian, French, Latin America, and Turkish. For non-contact cultures, touching is reserved for only the most intimate acquaintances. Examples include the U.S., Norway, Japan, and most Southeast Asian cultures. As such the cultural setting will influence the results of the experiments that follow.

2. The Dyadic Distance experiment

2.1 Experimental stimuli, setup and participants

The location and stimuli are kept identical for both experiments. By simulating real-life conditions, both experiments measure the valuable ‘first encounter’ of a large group of passers-by, in a natural setting, with a research partner that wears one of five distinct dust mask typologies.

In both experiments the independent variables are the gender of the research partner (mask wearer) and the mask/no-mask conditions. All variables are manipulated between participants. We now discuss the stimuli, experimental setup and participants, which are the same for both experiments. After this overview we present each experimental technique separately.

Stimuli

Both experiments are repeated for five distinct mask types and a no-mask reference situation, as presented in figure 2. During the course of the experiments, we briefly incorporated a green respiratory mask (not depicted). This mask proved to be out of context for this experiment. Because the mask conditions did not interfere with each other during the actual experiments, we chose to exclude this condition from the experimental sample.

No-mask: reference condition (Referred to as 'no-mask')

White disposable dust mask: Headband behind the ears, no breathing valves. (Referred to as 'white mask')

Red Respro City mask: Neoprene cycling mask with breathing valves on both sides. (Referred to as 'respro mask')

Respro Bandit Scarf: Filter laminated between cotton materials of scarf. Printed pattern in dark grey and black. (Referred to as 'scarf mask')

Mask prototype 1: Transparent mask, mouth and nose are visible. Fine orange edge. (Referred to as 'prototype transparent')

Mask prototype 2: Transparent front with sporty looks and details. (Referred to as 'prototype sport')

Figure 2. The mask stimuli: five mask types and a no-mask reference situation

Experimental setup

In our attempt to simulate a real-life encounter, we took both experiments outdoors and selected a suitable city location. The location was selected in such a way that passers-by would experience as little visual and physical distraction as possible (i.e. physical obstructions, visually competing signals, or competing pedestrian circulation). Both experiments were set on a wide sidewalk close to the central railway station of Antwerp, Belgium. Pedestrian traffic on this 320 cm wide sidewalk is mostly one-directional and unhindered over a length of at least 10 m. The street had limited car traffic and potential effects of social insecurity were not present. Our research partner took a position next to the staircase of a metro exit. The 120 cm high wall of the metro exit provided a suitable surface for positioning the measuring device of the Dyadic Distance experiment. Measurements were done in one direction only.

These are the requirements that were observed while selecting the proper location:

- No object within a range of 500 cm of the research partner.
- No bad or extreme weather conditions while performing the experiments. Weather conditions were equal in both experiments and for the various mask conditions.
- We performed the experiments between 3 p.m. and 6 p.m. in the afternoon. At that time, pedestrian traffic proved to be constant on that specific sidewalk, resulting in a flow of approximately three passers-by per minute.

The research partner was dressed discretely and acted unsuspicious. These are the requirements that were accounted for in the selection and preparation of the research partner:

- No eye-catching or too colorful clothing
- No visual referral to subcultures or social groups
- Normal build: average in size, weight and attractiveness
- No extra accessories or visual attributes such as headphones, hats, bags, rucksacks, jewelry, piercings, tattoos, etc.
- No potentially stigmatizing physical conditions: physical abnormalities, smell, noises, etc.

In both experiments, the research partner oriented him or herself towards the approaching passer-by.

Participants

Due to the vicinity of the central railway station, this location presented us with a broad spectrum of participants, ranging in age, gender, and nationality.

The research was conducted on a sample of 392 passers-by for the Dyadic distance experiment and a sample of 480 passers-by for the Stain Dilemma experiment. All participants participated unknowingly and were unaware of the experimental setup or its intentions. Because the video images were used only as a visual backup, participants were not informed about the intentions of our research, nor did we ask permission to process the images. Male and female participants and partners were counterbalanced within each condition (no-mask, and the five mask conditions).

To qualify as a valid participant, passers-by had to conform to these specifications:

- People behave different if they are in a group. Due to these behavioral differences, only singular passers-by were included in the sample. Passers-by had to maintain an interpersonal distance greater than 150 cm in order to qualify as a singular individual.
- Passers-by walking in the reverse direction were excluded from the sample.
- Passers-by accompanied by an animal were excluded from the sample.

- Passers-by who were obstructed during the interaction were excluded from the sample
- Passers-by who encountered or were engaged in distracting activities such as listening to sirens, phone conversation, listening to music, or lighting a cigarette, were excluded from the sample.

2.2 Method

The dependent variable that was measured in this experiment is called the dyadic distance. By definition, a “dyad” is a collection of two people, the smallest possible social unit. As an adjective, “dyadic” describes their interaction. In this study we use the term “Dyadic Distance” to describe the shortest interpersonal distance between the two people of interest, the passer-by and our research partner (labeled as DD in figure 3).

The experiment registered the behavior of people passing by a partner wearing a dust mask in a discrete setup. During the course of the experiment the research partner was discretely occupied and did not make visual eye contact with any passers-by. The walking and staring behavior of the passers-by was registered by 2 HD cameras and provided us with rich user insights on the interaction. No further analysis was performed on these data. The dyadic distance was measured with a narrow beam ultrasonic sensor, wirelessly linked to a laptop. The output of this experiment consisted of the ratio scaled data of 392 participants, equally distributed over the various mask and gender conditions. Depending on pedestrian traffic, the registration of 60 participants for one condition took about 20 minutes.

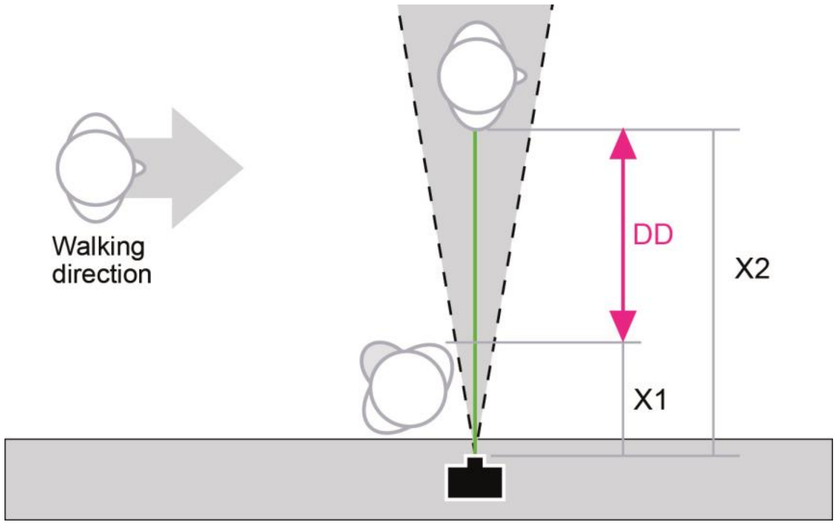

Figure 3. The experimental setup of the Dyadic Distance Experiment and the position of the ultrasonic sensor.

Equipment

Next to the stimuli, two research partners (one male, one female) and an independent researcher, the DD experiment required the previously mentioned DD-measuring tool and a laptop with DD-software and a Bluetooth connection. The DD-measuring tool was built on an Arduino platform and used a narrow-beam ultrasonic sensor suitable for in- and outdoor use (Maxbotic XL-Maxsonar WRC MB7081). A 9 Volt battery fed the system and to achieve a wireless connection, a Bluetooth module (BlueSmirf Gold) was added to the Arduino board. A switch on top of the housing allowed us to send two different data sets, allowing for a quick changeover between the various conditions. The Arduino board was programmed with PLX-DAQ software and fed its data to MS Excel. The DD-tool is straightforward to build with limited knowledge of electronics and it should not exceed a total cost of $300.

To avoid the deformation of the measurements, the presence of parking sensors, or other ultrasonic sources needed to be avoided. The DD measuring tool was placed at a distance of about 15 cm in front or next to the research partner (see figure 4).

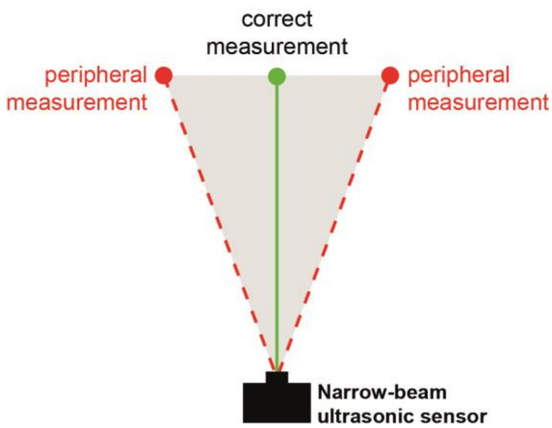

Figure 4. The DD measuring tool

Procedure

Once the DD-tool was positioned, it followed a specifically programmed calibration sequence to determine the initial distance towards the opposing wall or object. After the calibration session, the sensor takes two measurements per second. It takes about a second for a passer-by to pass through the field of the sensor, resulting in one to three measurements per participant. During the experiment the independent researcher was responsible for the elimination of false or peripheral measurements. This real-time assignment was subtly executed from a distance of at least 5m from the interaction. Analyzing camera images can also do this evaluation. Both methods are suitable as long as they do not influence the experiments.

During the experiment the researcher assigns a gender code to each valid passer-by and selects the correct DD measurement from the set of maximum three measurements (the lowest value), thus eliminating the peripheral measurements of the sensor (figure 4).

For each of the six conditions, at least 30 samples were registered with both a male and a female research partner. In each mask condition/research partner gender combination, male and female passers-by were separately counted and registered (figure 5).

Gender research partner / mask-condition / gender passer-by										
Gender research partner			Mask condition						Total
			No-mask	White mask	Respro mask	Scarf mask	Proto Transp.	Proto Sport	
Male research partner	Gender of passer-by	Male	30	21	23	17	17	15	123
		Female	11	12	10	13	13	15	74
	Total		**41**	**33**	**33**	**30**	**30**	**30**	**197**
Female research partner	Gender of passer-by	Male	20	20	19	15	20	24	118
		Female	10	12	19	14	13	9	77
	Total		**30**	**32**	**38**	**29**	**33**	**33**	**195**
								Total observed participants	**392**

Figure 5. Experimental conditions of Dyadic Distance Experiment

2.3 Results

Our hypothesis predicts that in an experimental setup, cleared of external influencers, a passer-by will maintain a greater (safer) walking distance from a research partner who wears a dust mask. In addition, it would be interesting to discover significant differences in interpersonal distance between the mask conditions and variances related to the gender of the participants or partners.

Prior to the validation of our hypotheses, we determined whether the gender of the partner or passer-by significantly interacted with the parameter of interpersonal distance.

After analyzing the results of 241 male and 151 female passers-by, a two-way ANOVA, with dyadic distance as the dependent variable, showed no interference between the gender of the passer-by and the mask condition ($F(5) = 1.794$, $p = .113$).

These results enabled us to derive conclusions related to the different mask conditions that mutually apply to both male and female participants. Adding the male and female samples generated a bigger sample for each condition and increased the accuracy of further statistical analysis. However, for the post-hoc analysis of the variance in dyadic distance among the various mask conditions, it can be interesting to separately evaluate male and female participants.

The DD was measured as portrayed in figure 3 and represented the closest distance between a research partner with mask and a passer-by. The box plot in figure 6 depicts variances in dyadic distance for each mask condition (male and female participants are merged).

Using Fisher's Least Significant Distance (LSD), a post-hoc analysis compared the mask conditions in pairs and exposed significant interactions between mask pairs. After each LSD analysis, we integrated a visual interpretation of the findings. The figure below each LSD-table visually groups the mask conditions by their average mean dyadic distance. Each group clusters mask conditions for which the mean dyadic distance does not differ significantly.

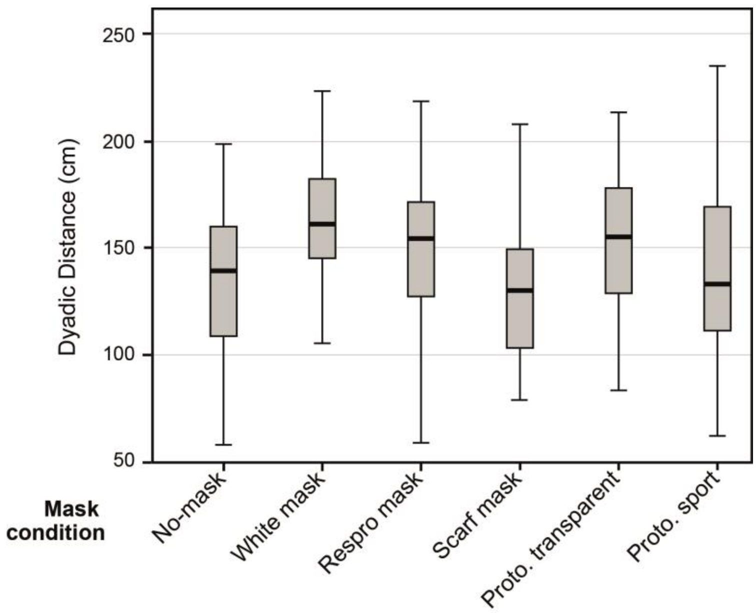

Figure 6. Box plot – Dyadic distance / Mask conditions.

Result DD-experiment – Male participants

Analyzing male only participants, ANOVA indicated significance ($F(5)=3.301$, $p=0.007$) between mask conditions. Post-hoc analysis with LSD rendered the table below, displaying the significant relationships in green. From the 15 possible combinations, five combinations had dyadic distance measures that differed significantly ($p<0.05$) (figure 7).

Significance between mask conditions – only male participants (passers-by)						
	No-mask	White mask	Respro mask	Scarf mask	Trans. proto.	Sport proto.
No-mask						
White mask	0,008					
Respro mask	0,065	0,431				
Scarf mask	0,952	0,012	0,078			
Transparent prototype	0,219	0,191	0,588	0,230		
Sport prototype	0,350	0,001	0,010	0,416	0,045	

Figure 7. Table with the result of the DD-experiment – Male participants.

Result DD-experiment – Female participants

Analyzing female only participants, ANOVA indicated significance ($F(5)=8.916$, $p<0.001$) between mask conditions. Post-hoc analysis with LSD rendered the table below, displaying the significant relationships in green. From the 15 possible combinations, 10 combinations had dyadic distance measures that differed significantly ($p<0.05$) (figure 8).

Significance between mask conditions – only female participants (passers-by)						
	No-mask	White mask	Respro mask	Scarf mask	Trans. proto.	Sport proto
No-mask						
White mask	0,000					
Respro mask	0,020	0,036				
Scarf mask	0,129	0,000	0,000			
Transparent prototype	0,002	0,260	0,343	0,000		
Sport prototype	0,030	0,035	0,928	0,088	0,316	

Figure 8. Table and graph with the result of the DD-experiment – Female participants.

Result DD-experiment – Male and female participants

Analyzing both male and female participants, ANOVA indicated significance ($F(5)=8.677$, $p<0.001$) between mask conditions. Post-hoc analysis with LSD rendered the table below, displaying the significant relationships in green. From the 15 possible combinations, ten combinations had dyadic distance measures that differed significantly ($p<0.05$) (figure 9).

Significance between mask conditions – male and female participant (passers-by)						
	No-mask	White mask	Respro mask	Scarf mask	Trans. proto.	Sport proto.
No-mask						
White mask	0,000					
Respro mask	0,007	0,048				
Scarf mask	0,249	0,000	0,000			
Transparent prototype	0,005	0,088	0,829	0,000		
Sport prototype	0,538	0,000	0,045	0,088	0,031	

Figure 9. Table and graph with the result of the DD-experiment – Male and female participants.

Analyzing the three clustering figures we observed that the following masks conditions appeared in the same group for nearly each situation:

- No-mask / Scarf mask / Sport prototype mask: these three mask conditions engendered the lowest dyadic distance-values in bystanders for each situation (male participant / female participant / male + female participant). The scarf mask had the lowest dyadic distance value, followed by the no-mask condition.
- Respro mask / transparent prototype: both these mask conditions scored mid-range values.
- White mask: the white mask scored the highest average dyadic distance in each situation and was clustered with the transparent prototype.

2.4 Discussion Dyadic Distance Experiment

The result of the DD-experiment led us to infer that avoidant behavior of passers-by towards users of dust masks, expressed by the dyadic distance parameter, can be measured. The average dyadic distance between the white mask and the no-mask reference condition differed about 30 cm. In contrast with our expectations, the no-mask condition did not engender the smallest dyadic distance. The scarf mask generated the smallest dyadic distance in each condition. The other mask conditions all differ about 15 cm from the no-mask reference condition.

The most general and valuable conclusion from the DD-experiment was the detection of three groups of masks that revealed no reciprocal significance.

The results of our subsequent exploration, the Stain Dilemma experiment, will either confirm or disconfirm these initial findings. Because both experiments were set up to be comparative, we will elaborate on the final results of both experiments in a joint discussion and conclusion paragraph at the end of this paper.

3. The Stain Dilemma Experiment

3.1 Experimental stimuli, setup and participants

The experimental setup, location, stimuli and participants are identical to the DD-experiment (See paragraph 2.1).

3.2 Method

The measurement of interpersonal distance with the dyadic distance technique delivered an accurate dataset for each mask condition. The next experiment focuses on the thoughtful and unconscious decisions that are made during a social interaction. When we walk around, our brain is constantly scanning and analyzing our visual surroundings. In 1971, Goffman already pointed out that the study of walking behavior might deliver interesting insights in the study of social stigma.

The ‘Stain Dilemma’ experiment reduces the input variables to a minimum and focuses on the walking path of the bystander as he passes a person who uses or wears a stigma-eliciting product. By placing a physical obstruction in the walking path, the passer-by is forced to walk around the obstruction or in between the obstruction and our research partner.

The avoidance of a stain has a lot to do with common sense, fear of mess and possible slipping. We were not primarily interested in the avoidance of the stain, but on the uncomplicated and effortless choice that is presents to the passer-by. However trivial this dilemma might appear, it proved to have an influence on the choices and behavior of the passer-by.

Equipment

The ‘Stain dilemma experiment’ requires little equipment and setup. The most crucial object is the physical obstacle that is introduced in the walking path. The obstacle was to be easily detectable, without being suspicious or alarming. In city life, pedestrians are often confronted with unpleasant spills and obstacles on the sidewalk. The experiment relies on the pedestrians’ subtle awareness of these familiar obstacles, and their intent to avoid them in an almost routinely way. Because our experiment was setup close to the railway station, in the presence of many food and beverage stalls, we chose to imitate a spilled milk shake. We avoided the use of unpleasant animal or human droppings to avoid any negative connotations with our research partner. This connection could activate unwanted disease avoidant behavior in the passer-by. A spilled milk shake is no anomaly on a city sidewalk and does not allocate many cognitive resources as the passer-by approaches and avoids it. We labeled our obstacle the 'fake shake' and positioned it on the border between the personal and social space (Hall, 1996) surrounding the research partner.

The 'fake shake'

The 'fake shake' is a realistic imitation of a strawberry milkshake, including cup and straw (see figure 10). We chose a bright and contrasting color to increase the chances of visual perception. The shake is made from a mixture of acrylic paint and other additives to give it the right texture, solidity and shine. A plastic cup and straw were added to increase the reality of the object.

Figure 10. The 'fake shake'.

For visual reference and in order to collect 'rich'-data, the experiment was registered with an invisible HD camera. The camera registered the passers-by as they approached our research partner (see figure 11). In its most elementary version, data collection requires no more than a pencil and a piece of paper. Additionally it is possible to develop a smart phone application for easy mobile data registration and analysis.

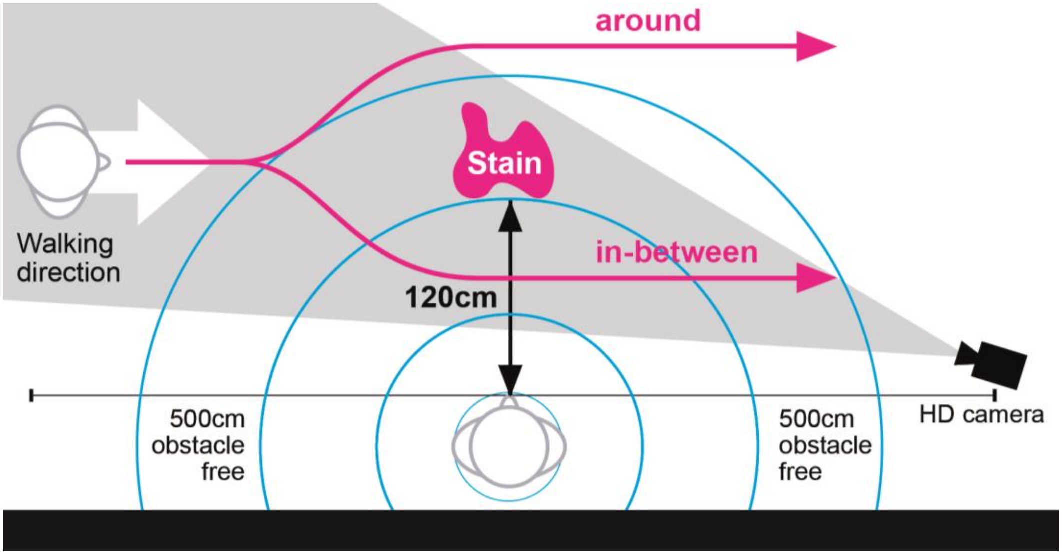

Figure 11. Experimental setup of the Stain Dilemma experiment.

Procedure

To qualify as a valid participant, a passer-by had to singly approach our research partner, without being obstructed during the full length of the interaction process. As with the DD-experiment, both male and female participants were recorded. The amount of participants averaged about 40 for each mask and gender condition, bringing the total amount to 480 participants (see figure 12).

Data registration was limited to two variables: the gender of the passer-by (male or female) and the path (around the stain or in between stain and partner).

Gender research partner / mask-condition / gender passer-by									
			Mask-condition						
Gender partner	Gender passer-by	Reaction passer-by	No-mask	White mask	Respro mask	Scarf mask	Proto transp.	Proto Sport	Total
Male research partner	**Male**	Around	13	20	11	19	15	17	**95**
		In-between	11	3	10	9	7	7	**47**
		Total	**24**	**23**	**21**	**28**	**22**	**24**	**142**
	Female	Around	11	11	14	9	9	13	**67**
		In-between	5	6	5	3	9	3	**31**
		Total	**16**	**17**	**19**	**12**	**18**	**16**	**98**
Female research partner	**Male**	Around	6	20	17	16	12	13	**84**
		In-between	13	1	9	12	12	11	**58**
		Total	**19**	**21**	**26**	**28**	**24**	**24**	**142**
	Female	Around	8	18	10	9	9	11	**65**
		In-between	13	1	4	3	7	5	**33**
		Total	**21**	**19**	**14**	**12**	**16**	**16**	**98**
								Total observed participants	**480**

Figure 12. Experimental conditions of Stain Dilemma Experiment.

3.3 Results

The hypothesis of the stain dilemma experiment predicted that when a mask is appraised as stigma-sensitive, a passer-by will actively avoid entering the personal space of the research partner. By walking around the stain, through the social space, a passer-by demonstrates that he prefers to avoid the user of the dust mask.

As was the case with the DD-experiment, we analyzed additional differences between the mask conditions and variances related to the participants or research partners' gender.

The influence of the partner's gender on the participant's reaction (around/in-between) was analyzed with a chi-square test with continuity correction. Only the no-mask condition displayed significant interaction between gender and reaction.

Further analysis was performed on the combined samples of male and female partners.

Result stain dilemma experiment – Male and female participants separately

After analyzing the result of 284 male participants, a chi-square test with continuity correction revealed no significant differences in the reactions to the different mask conditions ($chi^2(5)=5.470$, $p=0.361$). The results of the female participants (196 samples) did reveal significant differences in reaction ($Chi^2(5)=33.011$, $p<0.01$). We especially noticed the apparent result for the white mask condition. Only 2 out of 40 female participants felt comfortable to enter the personal space of the wearer of the white dust mask (figure 13).

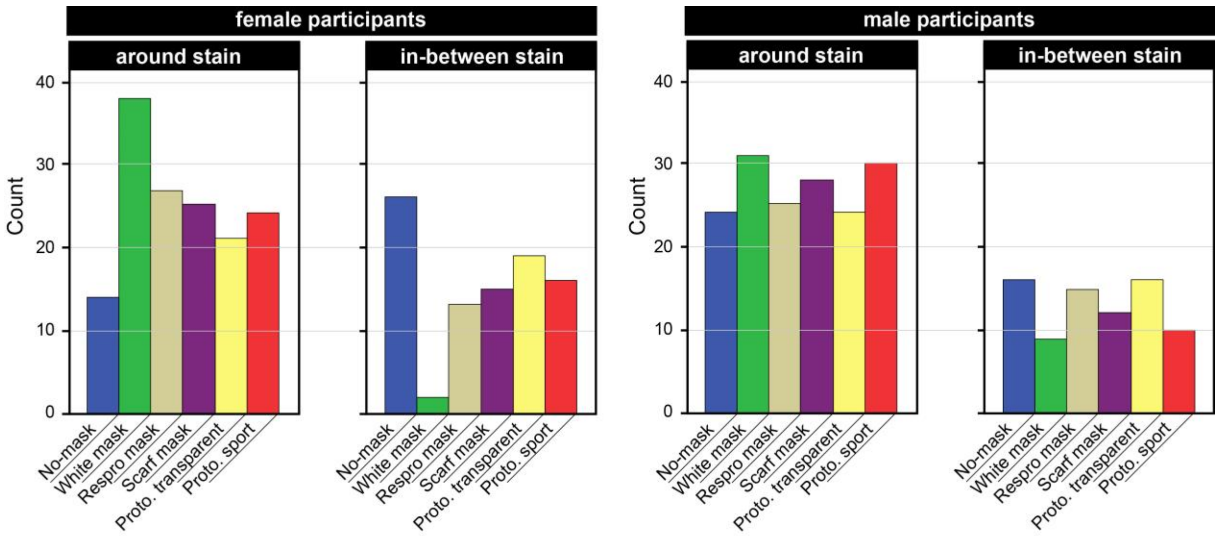

Figure 13. Count around and in-between stain for female and male participants separately

Result stain dilemma experiment – Male and female participants combined

The results of the combined analysis of male and female participants (480 samples) are visualized in the bar-diagrams of figure 14. A chi-square test with continuity correction for the entire sample (male + female participants) indicated that the participant reactions differed significantly for certain mask combinations ($Chi^2(5)=29.526$, $p<0.01$). A two-sample proportion test was used to disclose the proportional differences in reactions towards the different mask conditions. To reduce type 1 errors, the alpha value was lowered to account for the cumulative effect of the different mask combinations (alpha

= 0.05/(5+4+3+2+1)) = 0,0034). The table below displays the significant differences in proportion between the mask combinations (< 0,0034). Similar to the analysis of the DD-experiment, the results of the analysis allowed for a clustering of mask conditions that did not reveal significant interaction among each other. The clustering revealed three groups. In a first group we situate the no-mask and transparent mask conditions. For both these masks participants felt most comfortable to enter the personal space of the mask wearer, i.e. between stain and mask wearer. A second group bundles the scarf mask, sport prototype, and Respro mask. The white mask condition is isolated from the other conditions, with 69 out of 80 passers-by walking around the stain.

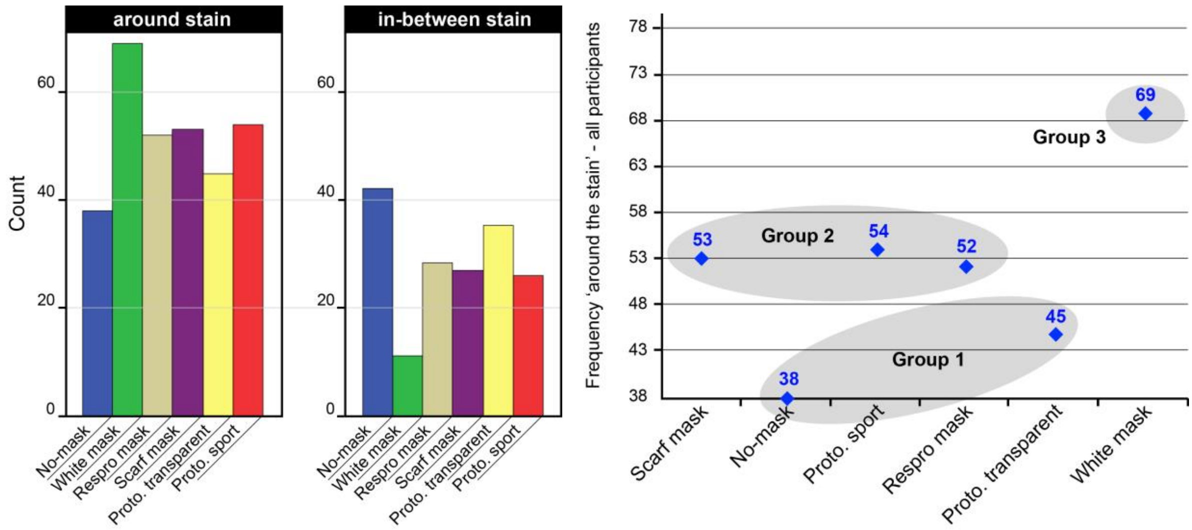

Figure 14. Count around and in-between stain for female and male participants combined / Visual grouping of the count 'around the stain' for all participants and mask conditions

3.4 Discussion Stain Dilemma Experiment

The results of the stain dilemma experiment revealed significant proportional differences in the reactions to the no-mask and white mask conditions. The other mask conditions positioned themselves in between these extremes.

Although the analysis of the reactions of the male population did not reveal significant differences, we mention that in four out of six conditions their reactions scored proportionally higher in comparison to the female participants. This could indicate that in general passers-by are less inclined to enter the personal space of male individuals.

4. Discussion of Dyadic Distance and Stain Dilemma Experiment

Both experiments illustrated that they can be effective in assessing and measuring avoidant behavior of bystanders towards dust masks. A remarkable observation was that the average interpersonal distance as well as the proportion of people walking around the stain was always greater in a setup with a male research partner. Male research partners, independently of the mask they wore, always seemed to increase avoidant behavior in bystanders. Literature in social psychology confirms such behavior around men and suggests that it is linked to the social power or menace engendered by the male species (Dabbs & Stokes, 1975). This passive 'force' endues men with a greater social space and could clarify why passers-by will maintain a greater distance from them. Because our experiments only allowed for an avoidance area of no more than 320 cm, this effect compressed the 'comfort zone' around our male research partners. This effect has to be taken into account in future explorations.

In an analysis of the mask groupings that were made for both experiments, it is possible to determine areas of convergence between the different mask conditions.

Figure 15 represents the results from both male and female participants. The horizontal axis represents the DD-experiment and indicates the average dyadic distance for each mask condition. The scale starts at 120 cm, which is the border between the personal and social space (Hall, 1966), and runs up to 170 cm.

The vertical axis represents the Stain Dilemma experiment and indicates the relative count of passers-by walking around the stain. The scale starts at 38, which is the amount of passers-by who walked around the stain in the neutral condition. Because the samples for each mask condition were identical in the stain dilemma experiment, the count can be interpreted as proportionate.

Figure 15 aims at visualizing the 'degree of acceptance' or the 'degree' of product-related stigma of a mask type with the aid of a gradient scale. Products that reside in the green part are considered to be acceptable, resulting in a regular interpersonal distance. As a product migrates to the red area, it becomes less accepted, accompanied by a greater dyadic distance and a larger number of people walking around the stain. If a product ends up in the grey zone, close to the axes, the validity of the results should be questioned, because this would mean that the results of the two experiments are opposed, which is unlikely. The gradient representation allows for a straightforward interpretation and communication of the experimental findings, ideal for meetings with stakeholders.

The combined visualization in figure 15 also aids in exposing inconsistent results for certain mask types. The further a product moves away from the centerline, the less consistent its experimental results are. A mask can score a low average dyadic distance, together with a high number of passers-by walking around the stain, and vice versa. A closer look at the instances prior to visual contact could clarify these findings.

If there are no striking features that visually alert a passer-by, he or she will approach the mask wearer as a 'normal' person. In this situation it is plausible that the decision to divert from the walking path will be made at the last moment. This could explain why the scarf mask, which nicely blends with its surroundings, engenders a low dyadic distance measure, combined with a high count of people walking around the stain. The scarf is only noted as unnatural or awkward when the passer-by is relatively close, promoting his 'last-minute' decision to walk around the stain. An opposite scenario can be observed for the transparent prototype that combines a substantial dyadic distance with a low count of people walking around the stain. Due to its brightly colored edge and its medical-like transparency, this mask has the potential to attract attention from a greater distance, a possible explanation for the greater dyadic distance. However, the soft looks and the visibility of facial features might comfort the passer-by as he or she approaches. These traits will increase the 'warmth' dimension of the wearer, encouraging the passer-by to pass between the stain and the mask wearer when forced to make a 'last-minute' decision.

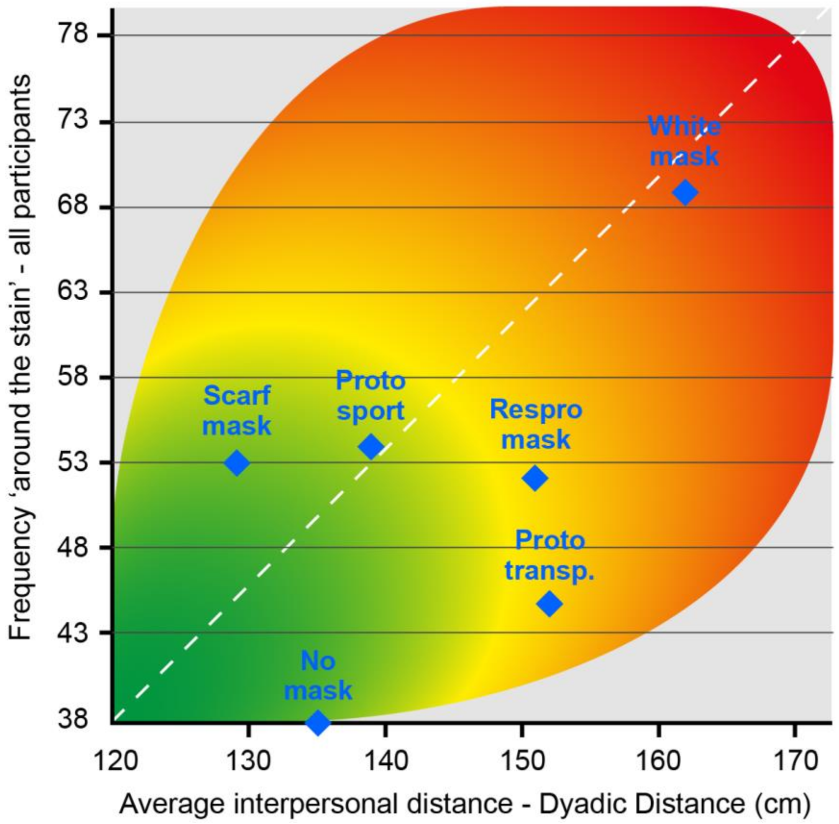

Figure 15. Combined experimental results: proportion around the stain x average interpersonal distance.

5. Conclusion

Both experiments prove that it is possible to measure significant differences in the behavioral reactions of bystanders towards users of stigma-sensitive products. The results suggest that the interpersonal distance between the product user and those who pass them is a valuable measure to quantify the 'degree' of product-related stigma.

We suggested that an accurate detection of the interpersonal distance could be obtained with a perpendicular measurement received from an ultrasonic sensor. We labeled this parameter the 'Dyadic Distance' and our experimental findings suggested that registering 30 participants for each human-product condition should suffice. The average dyadic distance between a passer-by and user of a white mask, compared to the no-mask reference condition differed about 30 cm.

The stain dilemma experiment can be interpreted as a simplified as well as a complementing experiment. An eye-catching stain positioned on the border between the user's personal and social space, forces passers-by to choose a path. The path around the stain presents the 'safe' option, indicating the desire to avoid the user and his product. The path through the user's personal space will be chosen when passers-by feel comfortable around the user/product combination. Because the stain dilemma experiment only renders binary results, it requires a larger sample for each condition. We advise to sample at least 40 participants for each human-product condition.

The experiments are conceptualized for efficiency (in time and resources) and allow for testing in a public setting that approaches real-life conditions.

Both experiments do not aim to deliver meticulous data by which stigma-sensitive products can be accepted or rejected. Nor do they provide the designer with exact information on which design features engendered the recorded reactions in bystanders. Nevertheless, these experiments have proven to be valuable in ranking a set of design proposals or products. By exposing products on a user, in realistic settings, and subjected to a large number of passers-by, the experiments can provide quick and valuable insight for designers.

We do note that the cultural setting will influence the results. As such, experimental findings cannot be extrapolated outside the cultural setting in which the experiment is setup.

During our experimental explorations we focused on the reactions engendered by existing dust masks as well as early prototypes. In future iterations, we would like to explore the relevance of our experimental techniques for other stigma-eliciting products that are visual to bystanders, such as crutches, prosthetics, hearing aids, etc. Apart from measuring product-related stigma elicited by protective, medical and assistive devices, the techniques we have applied could have a wider range of applications, e.g. in fashion, for wearable technology and law enforcement products.

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Towards more culturally inclusive communication design practices: exploring creative participation between non-Indigenous and Indigenous people in Australia

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Abstract: Currently, Aboriginal and Torres Strait Islander narratives and participation within communication design practices in Australia are scarce. The Australian communication design industry, currently reinforcing Eurocentric practices, needs to develop a better understanding of the social and cultural dimensions of design and to provide more inclusive practices for designers from underrepresented or marginalised groups. Through case study analysis, this paper explores and discusses a more inclusive way of working with Indigenous people and content within communication design. It draws from and applies principals of Transformative Participatory Action research to communication design practice – a more inclusive model for Indigenous creative practice within Australia. This approach moves away from co-design and participatory design models to focus more on participatory action, active engagement and empowering Indigenous communities through design.

Keywords: Communication design; Inclusive design; Transformative Participatory Action; Indigenous

1. Introduction

Within current communication design practices, the representation of Indigenous narratives is marginalized, as the ethical and respectful use of Indigenous iconography and culture is often overlooked in favour of Western standards and practices[225] (Jojola, 2011). The

[225] Philip Megg's *A History of Graphic Design* in 1983 solidified a graphic design canon that privileged Western practice and a modernist aesthetic-based valuation (Meggs, 1983). With its roots in the Industrial revolution, communication design practice has since been documented in relation to Western industrial societies. Design practices and structures, stemming from Modernism, in particular the Bauhaus, are still taught today, reinforcing design's Western origins and practices. Herbert Bayer and the Swiss Style of typography are

Australian communication design industry has historically had limited understanding and lacked influence from the important cultural and creative source of Indigenous Australia. Isolated examples within the industry have made progress in recognising the need for indigenous participation and to provide more inclusive practices for underrepresented or marginalized groups. The design community should reflect the history, culture and society of Australia as communication design is a visible part of the ongoing living narrative of culture (Woodward, 2008).

Currently, Aboriginal and Torres Strait Islander narratives within contemporary communication design are scare. Additionally, the communication design industry has limited involvement in developing practices of working with Indigenous designers. As Vernon Kee describes, 'most Australians and most folk in graphic design have little or no understanding of the issues involved in working with Aboriginal people, design and artwork' (2013).

This discussion paper explores a more inclusive way of working with Indigenous people and culture within communication design, drawing from and applying principals of Transformative Participatory Action research. This approach moves away from co-design and participatory design models to focus more on participatory action and empowering Indigenous communities through design. It proposes that inclusive communication design practices require a framework of participatory action, based in active engagement, where marginalized voices (such as those of indigenous people) are empowered (Chilisa, 2012). Utilising a case study approach, this investigation examines different approaches to contemporary creative participation and creation with Indigenous people and culture from a range of fields.

The case studies explored in this paper will be divided into two parts. Firstly through examining case studies from Namibia, Canada, Malaysia and Argentina, alternative frameworks and methodologies are explored that would allow an Indigenous knowledge based approach[226] to working with Aboriginal and Torres Strait Islander people in communication design contexts. Secondly, looking into contemporary creative fields, including craft, new media production and design specifically within Australia, creative relationships between Indigenous and non-Indigenous people are discussed. These relationships foster the building of empathy, understanding and community.

The paper then explores and discusses a more inclusive way of working with Indigenous people and content within communication design practices. This approach would benefit

examples of modern practitioners and design styles, which are still regarded as the dominant standards within current Australian communication design education and practice.

[226] Norm Sheehan's Indigenous knowledge principals of respectful design, focus on ways of knowing and reiterate how representing Indigenous knowledge and culture should be done in respect on showing care and awareness in the way we identify, explore and assess meaning because we know our view is always incomplete (Sheehan, 2100, p. 68). He continues to describe how the concept of 'respect' is so sensitive and complex through visual and narrative approaches: 'Respect is based on this ancestral understanding that we all stand for a short time in a world that lived long before us and will for others long after we have passed' (Sheehan, 2011, p.69).

Australian communication designers through increased diversity in the creative process, alternative cultural values portrayed in design work and expanded intercultural opportunities in designer collaboration.

Little academic literature exists concerning specific frameworks that apply principals of Transformative Participatory Action within communication design contexts. This paper seeks to make a contribution to design discourse by exploring a more inclusive way of working with Aboriginal and Torres Strait Islander People. An improved understanding of ethical and inclusive ways of working with Aboriginal and Torres Strait Islander Peoples, and the visible participation of more Indigenous voices would contribute important strengths to design in Australia, extending its unique creative, cultural and social range[227]. Further research is required to test principals of Transformative Participatory Action research within the field and explore ethical ways of working with Aboriginal and Torres Strait Islander people within communication design in Australia.

2. Terminology

For the context of this paper, the term 'communication design' is used to encompass both graphic design and digital/interactive design, as the nature of the industry moves to include both print, digital, virtual and strategic outcomes across the discipline. Steven Heller in *Eye Magazine* defines the industry definition of 'communication design' as addressing the transition from old to new media and can include graphic design; illustration; advertising and publicity material; typography; interactive or environmental design including user interface and wayfinding, or any form of visual communication (Heller, 2007).

ICOGRADA, the world body for professional graphic design and visual communication defines communication design as an "intellectual, technical and creative activity concerned not simply with the production of images but with the analysis, organisation and methods of presentation of visual solutions to communication problems" (Icograda, 2007).

Additionally, it is important to position the use of the term 'Indigenous' within the context of this project. Throughout colonial history Australians have socially constructed various terms to refer to Indigenous peoples. For many, the terms 'Indigenous,' 'Aboriginal,' 'First Nations,' 'Native,' are used interchangeably. 'Aboriginal and Torres Strait Islander' is commonly used in Australia to refer to Indigenous people.

[227] There are a number of frameworks that advocate and facilitate the integration of cultural protocols, when working with, or researching Aboriginal and Torres Strait Islander people (Bostock, 1997; DHS, 2006; Janke, 2002; Scott, 2002). However, there are a lack of guidelines and codes of conduct when working with Indigenous people, their culture, beliefs and motifs within the field of graphic design in Australia (Australia Council, 2007; Janke, 1998; Kee, 2013).

3. Historical background

This paper will include a few key historical points to place the topic in context, but will not be looking over the extensive historical background and literature relating to the colonising history of Australia.

It is important to recognize the diversity and complexity of the many different Indigenous cultures in Australia. Ways of working with cultural issues and materials may differ between different Indigenous communities.

Australia is home to the world's oldest continuous living culture. A Wurundjeri/Yorta Yorta descendant from Swinburne University states:

> "Our Indigenous culture and history is one of our most precious cultural assets. However, the Australian community's knowledge of its Indigenous background is scant; the depth of tradition and history unique to this country, barely scratched. This wide gulf in awareness and understanding is one of the reasons why most non-Indigenous Australians remain unaware of the enormous challenges that so many Indigenous Australians face on a daily basis. The representations of Indigenous Australians in our mainstream media continues to perpetuate the false perception that 'real' indigenous culture exists only in remote Australia. The reality is that everyone in this land is standing on what was once Indigenous land" (Peters, A. 2011, p, 3).

Following the arrival of the European settlers, the Aboriginal population plummeted by about 90% and became increasingly marginalized—ranking well above the national averages in poverty, crime, and alcohol abuse statistics (Price, 2008).

The Reconciliation Attitude Barometer, (a tool to measure the progress of reconciliation between Indigenous and non-Indigenous Australians) found six out of ten Australians have had little to no contact with Indigenous people (Reconciliation Australia, 2012). There exists a chasm of understanding as well as fundamental misunderstandings. The barometer also reveals that the vast majority of Australians believe the relationship between Indigenous people and other Australians is important for Australia as a nation (Reconciliation Australia, 2012).

The gap in cultural power between dominant and marginalized elements in Australian society is likely to remain unequal while there is a lack of Aboriginal and Torres Strait Islander People creating their own representations. However, both partners must strive toward a better positioning and working relationship to allow Indigenous peoples control over their cultural heritage.

4. Case Studies

4.1 Frameworks and methodologies towards inclusive facilitation between non-indigenous and indigenous participants

The most noteworthy preface to any discussion of Indigenous peoples is that a universal Indigenous paradigm does not exist. The academic literature relevant to this project comes from a variety of disciplines but is primarily focused on creative or design outcomes where possible. This section provides a summary on the academic research that has been conducted on developing frameworks or methodologies for working on design or creative projects with Indigenous people.

Participatory design methods value local participation, learning through action, collective decision-making and empowerment through group activities. The traditional model for participatory design is described in Figure 1. Designers team up with users and selected stakeholders to do co-creation or, participatory design. Together, often in workshops, user needs and problems are identified and new solutions are developed. It is almost taken for granted that participants are available, have the skills for contributing to the design process, and will be able to work together in an egalitarian manner.

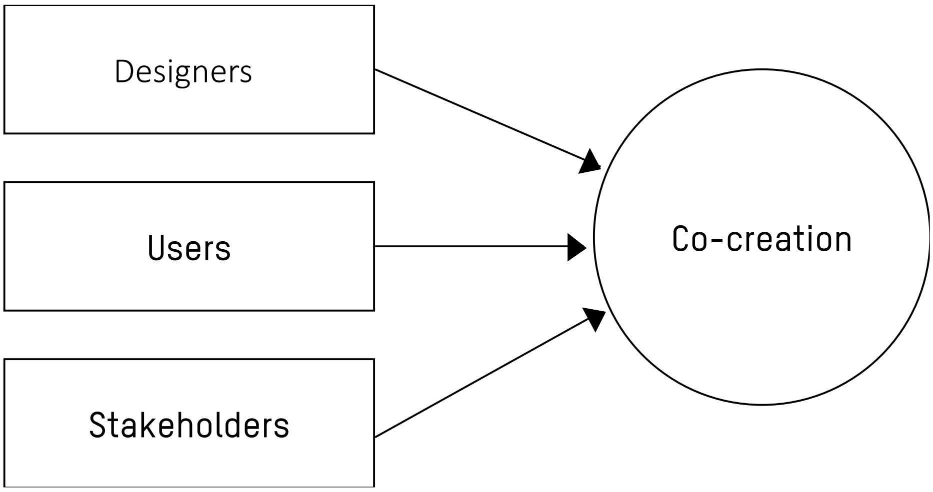

Figure 1. Traditional model for participatory design. This figure is based on a general understanding of participatory design often reflected in literature [derived from Figure 3 in (Sanders & Stappers, 2008, p. 11)].

Situated in Namibia, researchers Kapuire et al. explore participatory design with a specific focus on the benefits for participants and the community. Their aim was to co-design a digital system where community members can collect, curate and transfer Indigenous knowledge digitally to the next generation. Their study highlights that the concept of participation in itself is not universal. It is known that “cultural differences potentially affect the manner in which users are able to participate in, design, and act as subjects” (Oyugi et al., 2008). It has therefore been acknowledged that true participation, especially across cultural differences, can only be achieved if the participants are equally part of the decisions regarding the process and that the methods and concepts, or the ‘research problem’ itself are decided upon collectively before the project begins (Winschiers-Theophilus et al, 2010).

The researchers entered into a design dialog with the community so they could learn about their interests, skills and what benefits technology might offer them; to co-create a research question for the benefit of the community, not just the researchers’. Kapuire et al.’s project was carried out over a five-year period – time that allowed them to develop the project and to teach participants new technologies to aid community development. This time frame however conflicts with professional communication design practices as rarely are projects given such long timeframes to invest into community development or technology to improve participation.

Image 1. A participant(community elder) constructing a 3D scenario for his digital story in Kapuire, Winschiers-Theophilus, & Blake's 5 year study in Namibia.

Winschiers-Theophilus et al.'s associated co-design research in rural African communities highlights that while genuinely striving for user involvement, co-design methods can actually hinder a truly participatory approach to design (Winschiers-Theophilus et al, 2012).

Co-design methods value both the creativity of designers and people not trained in design, working together in the design development process (Sanders & Stappers, 2008).

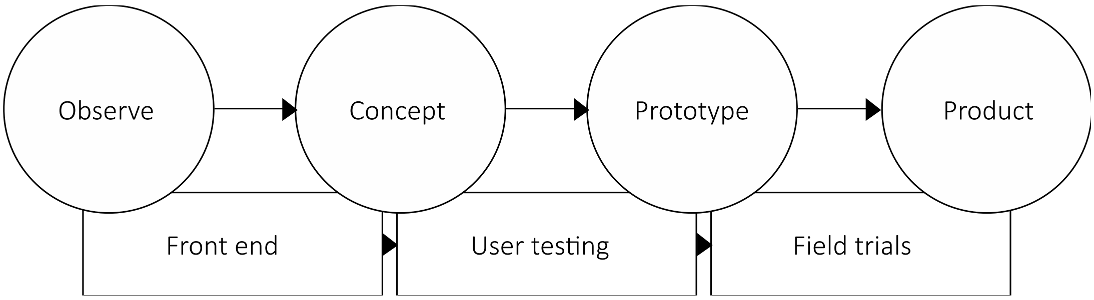

Figure 2. Model for co-design. This figure is based on a general understanding of co-design often reflected in literature [derived from Figure 2 in (Sanders & Stappers, 2008, p. 11)].

Winschiers-Theophilus et al. highlight the challenge of co-design lies in translating the local Indigenous knowledge system into an appropriate representation despite the fundamental epistemological differences (Winschiers-Theophilus et al., 2012). This is especially true when working with new technologies and new creative outcomes. How to translate local Indigenous knowledge into a new medium, where the researchers/designers are often those with the technical skills and thus the power to direct representations within a co-design environment.

The examples of both Kapuire et al. and Winschiers-Theophilus et al. highlight that both participatory design and co-design approaches seem to not truly invoke an inclusive design environment – with co-design not offering ongoing community benefits and participatory design lacking ethnographic approaches to participation itself. Both projects emphasize the need to focus on active community engagement and empowering indigenous communities through design projects.

Reitsma, Light and Rodgers' study on creating an exhibition with the Indigenous Penen community in Malaysia highlights the power dynamics inherent within co-design. Their study utilised design probes to gather cultural insights, but no ethical measures of interacting with the community are mentioned; only 'trust was not strong enough for them [the Indigenous community] to fully engage in the design probe activities' (Reitsma et al, 2014, p. 271). The lack of ethical and inclusive practices, led the community to take back creative control of the exhibition from the 'outsider' designer.

The designers had pre-defined the outcomes before consultation with the community, trying to fit Indigenous knowledge and local culture into already constructed project outcomes, without considering what the benefits were for the community. As the researchers describe:

"Before, the community tried to help the designer to create designs according to the expectations of the designer. But then one of the community members felt motivated to take the role of project manager from the designer. This shift was important, since it meant that the process was now in the hands of the community" (Reitsma et al, 2014, 272).

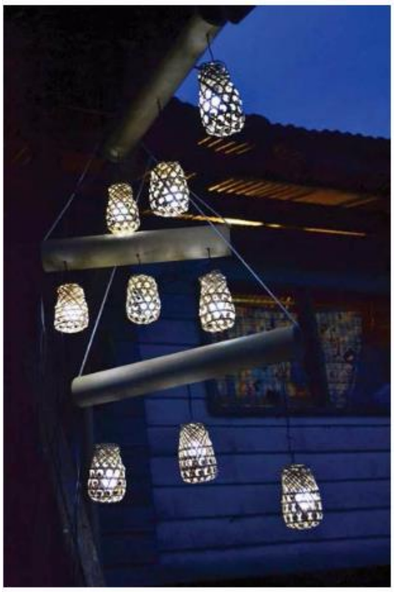

Image 2: Betunue' (fireflies): one of the pieces in a co-design project where drawings made by a Western designer, were translated into quick prototypes by the crafter, where the designer was seen as 'help[ing] the crafter to come up with her own interpretations' (Reitsma et al, 2014, 272).

This case study reflects the understanding that outsiders (the designers) are not experts on the indigenous community and that input from the community gives a richer representation of the cultural context (Sheehan, 2011).

Another project that highlights the inherent power dynamics within co-design or participatory creative projects is the work of Arnd Schneider on looking at Indigenous 'inspired' interior and accessories designs in Argentina. In *Beyond appropriation: Significant overlays in Guaraní-inspired designs,* Schneider argues that in this process of appropriating Indigenous designs from Northern Argentina, the meaning of the original design is suspended and ultimately short-circuited (Schneider, 2012, p. 346). Schneider details that the process of working with the cultural expressions of the Indigenous Mbya Guaraní is rationalised by the designers, as one of fusion and resignification.

Image 3: A table from Misiones Creativa, Cuña Pirú Lodge. Designers base their design on Guaraní culture without giving any more specific information. Therefore, what, as a Guaraní pattern, has very specific symbolic and mythological meaning has been turned through the design process, literally, into a decorative coffee table object. © Photograph: Arnd Schneider.

She argues the social co-participation from these co-designed objects does not signify equal shares of authorship, creativity and remuneration, but they stand more specifically for, and make more visible, the specific and unequal social relations between designers and Indigenous artisans (Schneider, 2012, p. 346).

Yet how to make this process more equal between Indigenous artisan and design is left unknown. The question still remains as to how to include symbolic Indigenous knowledge into communication design practices without concealing the acquisition of indigenous design, restricting space for expression or limiting either the artisan or designer's creativity. This example again highlights the power dynamic between the opposing artisan and the Eurocentric designer. It highlights how designers need to focus more on empowering indigenous creative practices, redress the inherent power imbalance, and to foster more ethical indigenous inclusion in design processes.

Through her research in working with Indigenous communities in Canada, Winnie Chow highlights how the practice of Western research and design often conflict with Indigenous circular ways of knowing (the way things are repeated and come around in a circle, showing us how we think and use information). Chow argues that a participatory action research framework attempts to address the unequal power structures inherent in indigenous/non-indigenous projects and moves forward from where Schneider left off.

Chow begins by entering herself as researcher into the study, which none of the previous cited authors had succeeded in doing, always placing themselves as 'other'. Chow explains "I enter into this study as a hybrid attempting to balance and attend to the needs of three complex worlds … Each world has its own codes of conduct and ways of knowing that often clash fundamentally" (Chow, 1995, p. 67).

Although Chow doesn't work within a specific design space, her Participatory Action Research (PAR) framework for approaching working with Indigenous communities could also apply to communication design as it advances respectful decolonizing practices and allows designers to position themselves respectfully within the project, being simultaneously mediators, designers and researchers.

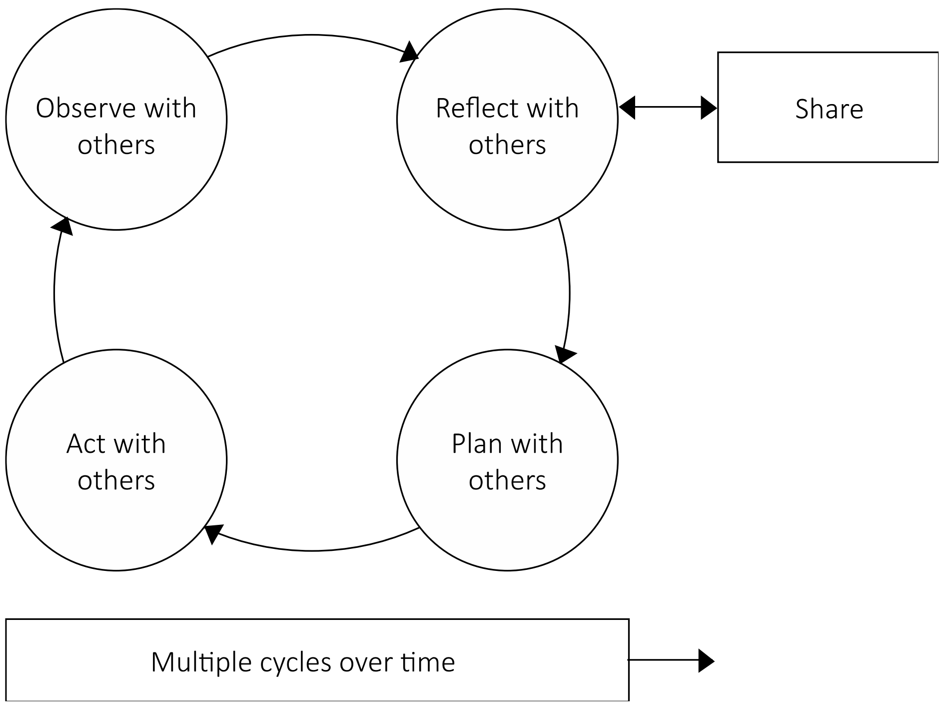

Figure 3. Model for participatory action research. This figure is based on a general understanding of participatory action research often reflected in literature [derived from Figure 5 in (Crane & O'Regan, 2010, p. 11)].

She includes her own lived experiences and acknowledges she enters as an ‘outsider’ yet includes a ‘reflection-in-action’ framework which embeds practical projects and experiences with Indigenous communities within an ongoing theory of action. Chow explains:

> “Through reflection-in-action, I put Participatory Action Research (PAR) theory in-use and confront the contradiction between theory and practice, thinking and action. This process led me to new ways of framing or testing the situation as I examined my tacit understandings, made conscious my underlying assumptions, and provided access to an alternative theory-of-action” (Chow, 1995, p. 68).

There is strong support by Indigenous groups and researchers for the use of PAR methodology (Hammersmith & Sawatsky, 1995; McShane & Hastings, 2004; Robinson, 1998; Smith, 2001; Smye & Mussell, 2001). Participatory action research starts with social concerns and lived experiences, values local knowledge and reconsiders the value of research as a vehicle for social change.

Insights gained from the case studies above, highlight there are fundamental clashes between codes of conduct and ways of knowing, between researchers, designers and Indigenous artisans and communities. The literature does not provide any concrete framework for bridging these differences, or moving forward. The approaches of Chow and Kapuire et al. are most useful, framing the designer’s role as one participant within the cycle, being able to be reflective throughout the process and acknowledging the community as an equal participant. Yet these approaches lack a specific ethnographic understanding into the idea of participation itself, who is participating and why - something that is critical when creating specific cultural outcomes, and when looking into current communication design practices.

4.2 Inclusive creative participation and creation within Australia

The second part of this paper addresses specifically Australian based projects, and focuses on contemporary creative mediums where possible. It is important to place these projects within a specific cultural context to relate the literature to specific ethnographically informed objectives and methodologies.

The history and practice of Indigenous research in Australia is intimately bound up with histories of colonisation, exploitation and abuse (Humphery, 2000; 2001). This has contributed to the devaluing of academic knowledge and status within some Indigenous communities, leading to suspicion and mistrust of research activities. Non-Indigenous academics and researchers have an obligation, therefore, to share their power with Indigenous communities.

In *The Jolt of the New: Making Video Art in Arnhem Land* Jennifer Deger highlights how non-traditional forms of creative expression can challenge the binary dynamics around academic/participant, artisan/designer, outsider/insider. Deger describes how “these technologies both provoke and enable putatively non-traditional forms of cultural production … new media technologies enable – if not demand – new modes of ethnographic engagement and response” (2013, p. 357).

Deger’s case study offers a positive alternative to co-creation with Indigenous people. It suggests that new means of creativity can create distinctive Indigenous forms of cultural production and social connection. Further, through working with communities on different mediums, such as video art, it can both provoke and enable non-traditional forms of cultural production that is in both parts enriching and stimulating to both indigenous participant and non-indigenous collaborator. This example highlights how changing the power dynamics between participant and designer is important in fostering Indigenous inclusion within Australian creative projects.

Image 4: Video still (detail) from three-screen installation Christmas Birrimbirr (Christmas Spirit). According to Paul Gurrumuruwuy: ‘We’re not just putting on Santa costumes. There’s more going on. Something deeper’. In Darwin, December 2011. Deger, 2013.

In addition to new media, Verran et al.’s study in digital knowledge describes how in Northern Australia many Aboriginal parents and grandparents are concerned that younger generations are growing up without a robust identity or a strong grasp of their community’s knowledge traditions. They endorse the use of computer databases and other digital technologies to work with audio files, texts, photos, videos, maps, lists, etc. to help with their work of teaching (Verran et al., 2007, p. 129).

However, Verran et al. also document suspicions that digital technologies can only work by treating indigenous knowledge as a commodity (Verran et al., 2007). These concerns grow from worries about disenfranchising Aboriginal knowledge, further marginalising legitimate Aboriginal interests, diversion of resources from Aboriginal priorities and misappropriation of intellectual property. These concerns exemplify the power dynamic of technology transfer, the subtle balance of control and its implications within Indigenous communities.

Describing the intertwined character of technology and indigenous knowledge, Daniel Fisher in his study *You Mob Listen* on Indigenous media in northern Australia discusses ‘newness’ in new media similarly to Deger’s work. He compares a live Indigenous cultural performance compared to a radio presentation – that the essence of the work is still present, just it is presented in a new medium, “his banter continues in between the songs’ verses, again echoing a radio DJ … it evokes how electronic media pervade a great range of Aboriginal expressive practice, and inform new intercultural arenas for Indigenous performance and belonging” (Fisher, 2005, p.1).

Discussing Indigenous representation and the creation of a national identity through design, Past President of ICOGRADA and academic and practitioner of communication design, Russell Kennedy describes that communication designers are wary of using any Indigenous image or work or even referencing Aboriginal iconography because of appropriation and ethical use issues (Kennedy, 2007, p.9). Kennedy’s academic research is in the area of cultural and national identity, in particular the relationship between the two.

Kennedy describes that there exists an ‘apartheid in design’ that discourages communication designers from incorporating Aboriginal culture into their work for fear of getting it wrong. He explains, “*Although completely understandable and respectful, this approach actually contributes to the invisibility of Australia’s Aboriginality and further widens the gap between Indigenous and non-Indigenous culture” (2007, p. 9).*

Kennedy looks further into developing an associated strategic innovation policy for the design profession, peak design bodies and government programs. This is positioned within a framework of interpretivism and stakeholder theory, based on mutual respect between parties (Kennedy, 2015). His proposal for protocols with professional practice highlight that communication design can recognise, respect and celebrate the centrality of Aboriginal and Torres Strait Islander culture, and although his protocols have yet to be implemented within industry, it positions a positive, strategic way forward.

Kennedy’s research work is so important in this context through recognizing that all stakeholders involved, from Indigenous communities, clients, design industry, industry leaders and communication designers themselves, need to move forward together and reposition Aboriginal content in contemporary communication design in Australia.

David Lancashire’s design studio has worked on numerous projects featuring Aboriginal and Torres Strait Islander motifs and iconography in Australian communication design. In 2002 David Lancashire Design developed an exhibition in the remote Pilbara region of Western Australia. In an interview with Eye Magazine, speaking of the project Lancashire stated: “Being a designer you are not dominant. You are actually more transparent. You say “What do you reckon?” rather than “I’ve done this design. I reckon we’ll do this” (Eye Magazine, 2002). Lancashire’s work is situated in an understanding that working with Indigenous communities requires observation of Aboriginal protocols, humility and patience.

Image 5: David Lancashire Design, Kanijiri Visitoss Centre, 2002. Source: www.davidlancashiredesign.com.au/disciplines/interpretation/karijini-visitor-centre

Lancashire's work highlights his personal journey and follows principals of self-determination and cultural ownership. However, these projects present the design studio as the primary designer and owner with questions arising around communal copyright and ownership over project outcomes. This example highlights that Lancashire's practice is not quantified through any series of working frameworks – it is his personal understanding of working with Aboriginal and Torres Strait Islander people within communication design contexts that has informed the framework explored in this paper, and the need to redress the power imbalance that is intrinsically linked to professional design studio outcomes.

The case studies analysis provides a survey of Indigenous creative collaboration, focused on new technology and new cultural production in Australia. From radio to new media, these projects highlight that designers can retain the essence of Indigenous culture into new mediums, such as communication design. It affirms that through new media, old forms of culture are not lost, and the ancestral essence of culture and country remains embedded within these new forms.

The examples highlight how redressing the power imbalance between designers and Aboriginal and Torres Strait Islander people and content is paramount when exploring inclusive ways of working within communication design. Ethical use issues around Aboriginal iconography may differ from community to community and thus is it essential to base a communication design framework in observation, reflection and planning, not just the design project itself.

This analysis also reveals a gap in the literature around exploring frameworks of Transformative Participatory Action within communication design practice. This approach has yet to be explored and tested. Additionally, it reveals a gap around Indigenous creativity within communication design being explored from Indigenous people and culture. It suggests a need to further explore nuances of the communication design profession and what are the opportunities and limitations for Indigenous groups working with the field.

5. Methodological approach: Framing Indigenous design perspectives

Research on Indigenous issues should be carried out in a manner, which is respectful and ethically sound from an Indigenous perspective. Providing a mechanism for Indigenous peoples to participate in and direct research agendas to ensure their communal needs are met, and that designers then learn how to build ethical relationships.

A decolonizing perspective is significant to this research because it focuses on Indigenous-colonizing relationships and seeks to interrogate the powerful social relationships that marginalize Indigenous peoples and specifically to decolonize, Euro-centric design education and practice within Australia (Nicoll, 2004).

Examining power relationships between Indigenous and colonising histories, especially within Australia, enables a framework that seeks out Indigenous voices and representations within a research field, that has historically marginalized and silenced Indigenous peoples (Smith, 1999).

In discussing the representation of Indigenous knowledge, the work of Smith in *Decolonizing Methodologies* is imperative in structuring this research from a decolonizing framework. Smith describes that Western research draws from an ‘archive’ of knowledge and systems and Western ways of viewing, talking about and interacting with the world at large are intricately embedded in racialised discourses that can lead to ‘stealing’ knowledge from Indigenous perspectives and re-presenting it in the wrong way and in the wrong place (Smith, 1999). As such, it is imperative to note my role as a Western researcher, and to understand my own cultural views, perceptions and beliefs that may impact on this research. Being aware of my role as researcher allows me to more objectively undertake culturally based research, knowingly approaching this project from the position as an outsider.

In Australia, methodological reform is also cited as a way of redressing the power imbalance between researchers and indigenous participants in research activity. The Deakin University Institute of Koorie Education, for example, argued that Indigenous research must move from “a positivistic positioning of Koories as objects of others’ enquiries to research paradigms which attempt to redress the oppressed, marginalised ‘border’ reality of Koorie nations in contemporary Australian society and within this society's academic institutions" (Deakin University, 1994, p. 4).

6. Theoretical Frameworks

Framing this project, from an Indigenous research perspective, flows from an Indigenous belief system that has at its core, a relational understanding and accountability to the world (Steinhauer, 2001; Wilson, 2001; Kovach, 2010, p. 42). It is grounded in an understanding that Indigenous methodologies are holistic and about the whole research process, not solely the creative outcome.

Bagele Chilisa, a Botswana-based scholar, in *Indigenous Research Methodologies* undertakes an extensive examination of Indigenous methodologies that draws on theories and practices from a variety of cultural and academic contexts. Chilisa's writing is premised on understanding how the researched and non-academic knowledge systems are experienced.

Chilisa describes that the guiding principles behind 'transformative participatory action research' are research for personal and social transformation and purposive active engagement and political action by both the researcher and researched (2013, p. 235). She continues to describe that in this approach "the poor and exploited are empowered to believe in themselves and to have the confidence and the will to conduct research on their own reality using their ways of knowing and to use the research findings to embark on positive social change" (2013, p. 235).

Embedded within a framework of creative participation, this approach to research, using Indigenous ways of knowing, explores how communities can use communication design as a tool of empowerment and positive social change. Through this notion of transformative participatory action within design, it is also imperative to look at practice-based theories as well as research frameworks.

In *The Reflective Practitioner*, Schon (1982) speaks to a generative inquiry approach for epistemology where 'knowledge is in the action' (p. 54). According to Schon, when someone reflects-in-action, they become a researcher in the practice context, not dependent on the categories of established theory and technique. Within practice-based research, Schon explains that the researcher does not separate thinking from doing, because experimenting is a kind of action (p. 68).

It's an interesting approach when considering what issues arise when Western and Indigenous research protocols, values, procedures, and ethics merge when creating communication design outcomes. This 'thinking on our feet' approach might be the best way of working together, to create an inclusive design outcome and industry. Further, as creative partnerships and practices are so hard to fit within protocols and frameworks of working, this approach allows for the project to develop naturally, not separating the theories with the practice of design and creativity.

Merging Chilisa's *Transformative Participatory Action Research* approach with Schon's *Reflection-in-action* presents us with a potential framework for inclusive communication design practices. It goes beyond co-design and participatory design to put the needs of the community or the marginalized group at the center of the project, with the designer (whether they are Indigenous or non-Indigenous) being able to begin the process without putting it 'in the too hard basket' for fear of getting it wrong (Kennedy, 2007).

This mix of acknowledging the community as an equal participant from the beginning of the project and learning through doing may allow communication designers a way forward to more inclusive practices. However as Chilisa's approach is paramount in the beginning and throughout the project, Schon's framework allows the designer to fit within the context of professional communication design practices – having the flexibility to meld and shape outcomes within industry.

When we look at combining the models, the linear process of design (highlighted in figure 4) typically moving from brief to outcome turns into a more circular process of ongoing participation and reflection.

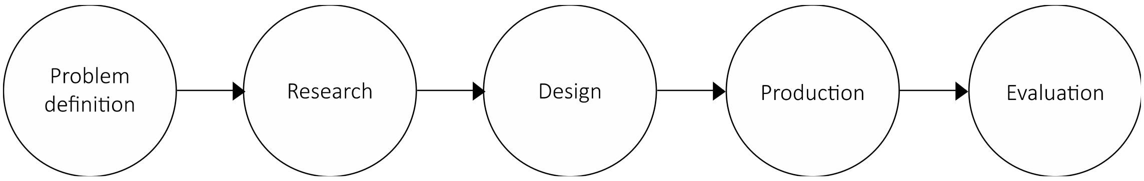

Figure 4. Model for communication design practice. In the academic literature there are many varying models on communication design practice. For the purposes of this study, a simple diagram has been utilised that contains many of the same components in a wide variety of communication design process diagrams. For clarity of this project, this model is based on a general understanding of the core elements of the design process. Derived from 'The Design Process' in (Meggs, 1992, p. 153).

7. Transformative Participatory Action model for communication design practice.

Figure 5 details a suggested model for a more inclusive design practice, based on an ongoing cycle of active participation and reflection. It draws from and applies principals of Transformative Participatory Action and reflection-in-action within a specific communication design context. It suggests the creative process is not just restricted to the 'design' component of a project – it can happen throughout, from observation, reflection and planning.

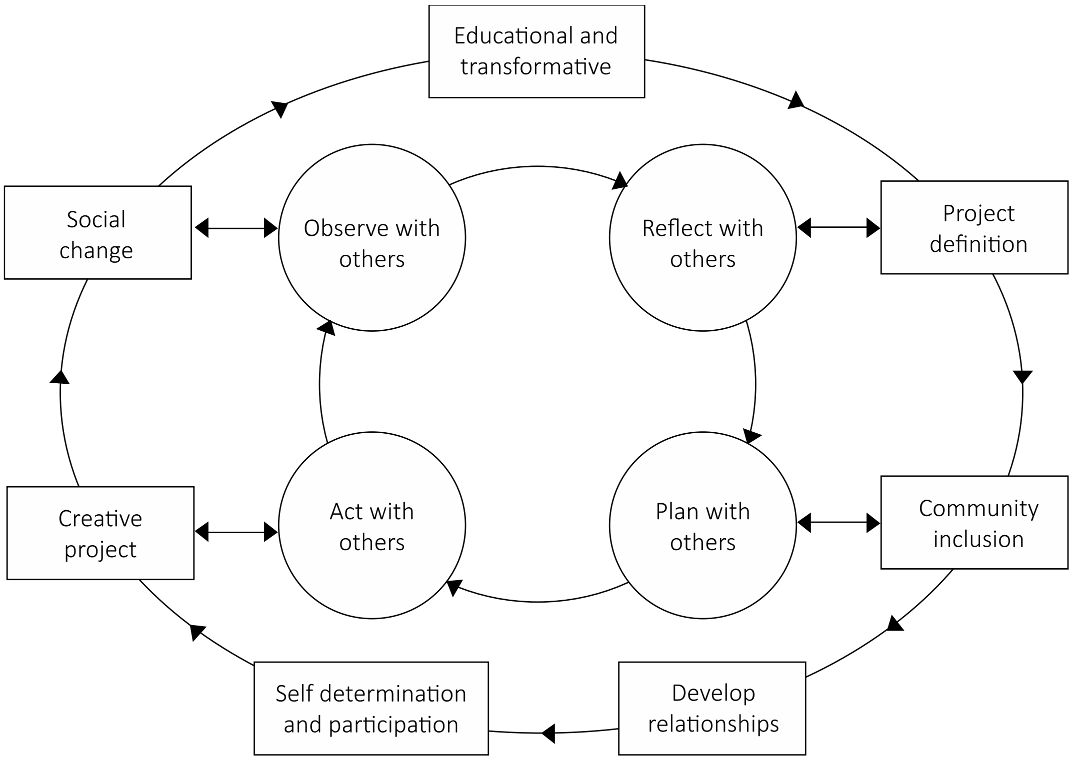

Figure 5. Transformative Participatory Action model for communication design practice. This figure is based on principals of transformative participatory research with a general understanding of current professional communication design process.

This proposed model is based in the understanding that the best way to learn is to do, and the best way to do is to learn. Through this proposed cycle, the 'doing' component, or the creative communication design project (the outer circle) is the actual creative process. Intrinsic to the 'doing' is the 'learning' (the inner circle), which follows the same cycle, to remain inclusive, to observe, reflect and plan while creating.

Communication designers bring to this process, their sensibilities, skills and experience within visual communication and their ability to mediate, synthesize and create a visual dialogue from diverse elements (van der Waarde, 2012). This synthesis of intellectual, technical and creative activity happens throughout the model, with the intrinsic skills of the designer being adept at overseeing the full design process. Additionally, the communication design brings experience with creative problem solving, analysis, organisation, evaluation and methods of presentation.

The proposed model highlights, that the creative process is not linear, there may be numerous 'inner' cycles before the 'outer' cycle of creative participation is engaged, but that the designer must value and move throughout both, with one reflecting the other. Additionally, there is no set starting point, that instead of the process being seen as too hard or culturally intimidating, that the creative project can begin with an observation, a reflection or a problem and undertaking a natural flow through conversation and education.

Often the logical starting point for communication design projects is in observing, responding to a creative brief or defining a problem area. Yet there can be no project definition without first observing and reflecting with others, creating true participation with co-creators or communities. This process fosters community inclusion and leads to developing better relationships between co-creators, stakeholders and clients.

This cyclic nature also allows co-creators the time to fully understand the benefits of the project in relation to self-determination and social change. Being able to not just create a creative solution, but have the time to transfer skills, create knowledge sharing and implement long-term educational and transformative outcomes to the project.

The creative project itself is only one component of the cycle, and co-creators must be aware of the whole cycle of design, you cannot just jump straight into the 'doing' without first observing, reflecting and planning with others. Nothing is done in isolation, and no one perspective is above another. This model also proposes that it is not the communication designer alone involved in the creative project or outcome. Co-creators and true participants in the process may not directly create an outcome, but their observations and reflections are key components in the process and crucial to the process of inclusive design practices.

The proposed model leads to a more inclusive communication design practice through:

- More unique creative projects, thus better client outcomes;
- Improved collaboration and true participation;
- Enhanced community capacity;
- A more responsive, improvement oriented culture, and
- Enabling community participation increases the likelihood that the approach taken will better suit local circumstances, and build real community 'ownership' and involvement.

It also allows the development of professional practice and the service based nature of communication design through:

- Encouraging a reflective, responsive and creative approach to communication design, such that insights are able to be acted upon to improve the quality of service offered to clients
- Providing opportunities for continuous evaluation and review of all aspects of the design process and outcome
- Enables the development of many new initiatives and projects by providing the legitimacy through evidence for why they might be necessary and why they ought to be developed in a particular way (Porter Orchard & Associates 2009: p.19)

The unique features of utilizing principals from Transformative Participatory research within communication design is a way of working together to make things better and involves a shift from "I ask … You answer" to "We explore" (Wadsworth, 2001, p.78). These reconnection and explorative experiences throughout the process are crucial in Indigenous contexts (Frazer, Gehan, Mills & Smart 2003). This process involves creation 'with' people.

The proposed framework, developed from insights gained from the literature review encourages more involvement, ownership and participation by the Indigenous community, the communication design community, and clients.

The potential limitations of applying principals of Transformative Participatory Action model within the context of communication design in Australia include:

- Navigating equal share of authorship and remuneration. How to ensure all contributions benefit from the creative project at both the individual and community level
- Specific community based social, cultural and political relationships may restrict participation
- The suggested framework would considerably extend a design brief and communication designers would need to navigate this with clients
- Ongoing communication and project benefits are not specified within this model

Further research is required to test this model in the field and to further develop ethical frameworks for working with Aboriginal and Torres Strait Islander people within communication design in Australia. Additionally, this model needs to be tested to examine how this framework would operate at the local community level and the cultural specifics of what this process might look like.

Additionally, specific research is needed on the unique role of the communication designer when working with marginalised or Indigenous people and culture - as their role merges researcher, co-creator and facilitator.

8. Conclusion

Communication design is an aspect and reflection of culture. What messages and campaigns are put out into the community need to embrace Australian culture, and the voices of its Indigenous People. In order to reduce racism in Australia, and to create more cultural empathy, Indigenous narratives need to be told, so as to encourage this dialogue and explore what Australian culture looks like from a contemporary communication design perspective.

This paper focuses on the facilitation of design outcomes with Aboriginal and Torres Strait Islander people, and the need to be based on the fundamental values of respect for human rights, equality and sustainability. The exploration of drawing from and applying principals of Transformative Participatory Action research, for a more inclusive way of working within communication design was developed from insights gained from case studies internationally, and specifically within Australia. This approach encourages more involvement, ownership and participation from both the Indigenous community and the communication design community of Australia.

Case study analysis highlighted how both participatory design and co-design approaches when working with indigenous people seem to not truly invoke an inclusive design environment – with co-design not offering ongoing community benefits and participatory design lacking 'true' participation across cultures. Additionally, studies consistently pointed to the unequal power dynamic between the opposing artisan or indigenous community and the Eurocentric designer.

Within Australia, studies emphasised the continued ancestral essence of culture and country within new forms of cultural production, including communication design. However, as each specific community has its own ethical use issues around iconography and culture, principals of Transformative Participatory Action research within communication design practice are essential to encourage active observation, reflection and planning with Aboriginal and Torres Strait Islander people within specific project contexts.

Drawing from and applying principals of Transformative Participatory Action research to communication design practice allows for a more inclusive model for Aboriginal and Torres Strait Islander creative practice within Australia. It seeks to address the power imbalance inherant within non-indigenous designers working with indigenous communities, people and culture. The cyclic nature of the proposed framework seeks to create true participation with co-creators or communities, foster active community inclusion, develop better reflective and responsive relationships between co-creators, stakeholders and clients and ultimately empower Indigenous communities through communciation design. Further research is required to test principals of Transformative Participatory Action research within communication design contexts and examine specific community and working relationships.

Finally, it must be suggested that the relationship between designer and audience, reflecting as it does the gap in cultural power between dominant and marginalized elements in Australian society, is likely to remain unequal while there is a lack of Aboriginal and Torres Strait Islander People creating their own representations. However, both partners must strive toward a better positioning and working relationship, to allow Indigenous people control over their cultural heritage and to extend the cultural and creative range of contemporary Australian communication design.

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Designing meaningful vehicle for older users: culture, technology, and experience

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Abstract: This study aimed to achieve understanding from the middle-aged vehicle users and from older vehicle users about differences between their current travel experience and future travel needs. A methodological triangulation consisting of interviews, logbook and co-discovery was used to collect multiple forms of data and explore the older vehicle users travel-needs-influencing factors within the Chinese cultural frameworks. This paper built a concept model to integrate these travel-needs-influencing elements that might give designers new knowledge to assist their innovations. It is envisaged that the proposed model can play an important role in the design process to help designers to better understand the relationship between culture, technology, older users' experience and design. The application of the model will focuses on designing meaningful concept vehicle for the older Chinese users as a representative example.

Keywords: vehicle design; product meaning; older vehicle users; experience design

1. Introduction

With one fifth of the world's population, China is the first-largest automobile market in the world in terms of the number of vehicle users. Its rapidly growing economy, rising consumer income, large number of aging populations and particular socio-cultural context present automobile manufacturers with enormous market potentials. It is important to note that the original Western or Japanese designed vehicles need to be redesigned or changed for the Chinese market. The optional design changes needed to adapt to local market factors, especially to local older users' needs, are more difficult to make because the required information is not available. Therefore, it is necessary to study older vehicle users' experience within the particular technological and cultural context.

Vehicle designers need frameworks for making transitions from theoretical understanding of older Chinese vehicle users to design implementation. The aim of this study is to explore the travel needs of older Chinese vehicle users, and to develop a theoretical model to synthesize older vehicle users' travel-needs-influencing factors which assist in designing meaningful vehicle for the target users. Margolin (2002) recognizes that today's artificial is a much more complex phenomenon than postulated by Simon (1969). An artefact's meanings become a strategic concept that exists pragmatically at the interface of design and use. Its value is determined by operation rather than semantic concerns (Margolin, 2002). The system of products is more coherent than the system of needs (Baudrillard, 1988). In order to explore the older vehicle user's needs, it is necessary to study meanings embedded in the product system and transfer meaning into the users' needs and experience.

2. Vehicle meaning structure and older users' needs

The product initially has no meaning in its own right and physical property. In using these products, users interact with the form of the object, which tells people about the functional and aesthetic design, the materials technology and the manufacturing techniques in the material culture of origin. These features of the material culture are embedded within the object and released as it is used (Dant, 1999). Therefore, artefacts are not only material objects, but also function as signs which both denote and connote meaning. The making of meaning is vital to the design process. Designers can be defined as cultural intermediaries who help users find meaning, identity and sense in a highly confusing world (Press & Cooper, 2003). Design innovations developed to cope with a specific problem have a way of changing the way people do things and of altering how they relate to each other; eventually they affect the way people experience their lives (Csikszentmihalyi & Rochberg-Halton, 1981). On the other hand, users can give to the object new meaning when they find new connections to their socio-cultural context and explore new symbolic values and patterns of interaction with the product.

Considering vehicle design issue, the automobile can be defined as a metal container that can be filled with any number of social and cultural meanings (Beckmann, 2002). The older vehicle user as a subject imposes his or her wants on the object and defines the car's uses according to his or her own needs. Simultaneously, the older user is defined by the vehicle's particular way of responding to the older user's needs. That is, a vehicle is used by many, and for many purposes. It is no longer only a machine for travelling through space, but a car that is 'constructed' to overcome a variety of other daily life problems. Vehicle designers take responsibility to translate multiple changes such as technology and material into forms with credibility and cultural validity (Sparke, 2002). The growth of economies and the unique cultural traditions in China at this time require China to distinguish itself both as a means of consolidating an eastern orientated identity for its elderly users and so show a distinctive face to the rest of world. On the other hand, vehicle meaning can be constructed differently due to different users' cultural backgrounds. From this point, do older Chinese vehicle users look on their private cars the same way that American users do? If cultural differences lead to meaning-making differences, why do older users who live in different cultural contexts drive similar vehicles designed by multinational vehicle manufacturers? These questions need to be explored through focusing on user–artefact meaning and user experience in different technological and cultural contexts.

3. Exploratory study

3.1 Research methodology

The experiment was divided into two sections (Sections A and B) in relation to investigating current older and middle-aged vehicle users' travel activities; and exploring the future older Chinese vehicle users' travel needs. A methodological triangulation approach consisting of interview, logbook and co-discovery helped to collect multiple forms of visual and textual data to explore the older users' needs. In Section A, the co-discovery method was employed to explore the older Chinese vehicle users' future travel-related needs. The participants were divided into eighteen groups to discuss and envisage their future travel activities and lifestyles, and sketch their own future car. Section B was designed to investigate present older and middle-aged vehicle users' travel patterns, experiences and needs. The interview and travel logbook are employed in the section B. This study involved eighteen middle-aged (45-59 years old) and eighteen older (60 years old and above) vehicle users. To ensure the research validity, the participants' pool cover different genders, educational backgrounds and occupations.

3.2 Data analysis procedure

This study utilized grounded theory (Strauss & Corbin, 1998) to analyze the travel activities of two age cohorts and compare travel-needs-influencing factors in different category levels. The data analysis procedures were based on three steps for interpretation of outcomes. In the first step, this study focused on transcribing verbal and textual data collected from the experiment, and developing a coding framework (Table 1) to start the chain of theory development. In the second step, themes and categories were related to their subcategories to form more precise explanations about travel phenomena. This study was designed to rate the themes from the point of view of frequency, and so identify the significant themes. The third step of analysis moved to cross-age comparisons and analysis at category, sub-category and conceptual levels. Frequencies of categories and sub-categories were compared across four participant groups: (i) between middle-aged vehicle users' current travel actives and older vehicle users' current activities; (ii) between middle-aged vehicle users' future travel actives and older vehicle users' future activities. Once the key factors emerged in such cross-age comparisons, the analysis focussed on producing an interpretation of these interrelationships and building a theoretical model to structure all categories from the design point of view. Current travel activities were used as a reference framework for comparison, because seeing into the future is easier if researchers have a clear view of the current situation (Press & Cooper, 2003). Atlas.ti was used in the coding and data analysis.

Table 1 Coding scheme.

Themes	Codes	Categories
Social practice	SAL	Social activity for maintaining daily routine life
	SRA	Social role adaptation
	SAP	Social acceptability
	SAS	Social accessibility
Local context	SEF	Socio-economic factors
	LGF	Local geography
	LCT	Local customs
Travel activity adaptation	TPT	Travel patterns
	DBV	Driving behaviour
Vehicle meaning	PMN	Practical meaning
	SMN	Social meaning
	CMN	Cultural meaning
Vehicle property	ECM	Economy
	STT	Structure
	FCT	Function
	TNG	Technology
	ATS	Aesthetics

4. Findings: older users' travel-needs-influencing categories

Central to the analysis of the data has been the identification of the factors influencing the needs of older vehicle users, and how the future older drivers' travel needs are shaped through interaction with vehicles. This identifies five travel-needs-influencing categories: social practice, local context, travel activity adaptation, vehicle meaning, and vehicle property involved. From these five themes, 17 codes were generated (Table 1). Through calculating the overall frequency counts of categories, vehicle meaning is identified as the most significant theme (Figure 1). Although these five travel-needs-influencing themes are mentioned with similar frequencies to each other for both age cohorts, their interpretations within their own categories and sub-categories differ. Figure 2 shows the integrated comparisons of travel-needs-influencing factors between two age cohorts at the category level. The higher frequency rate of occurrence of a particular travel-need-influencing factor shows its significance to the Chinese vehicle users travel needs. These five themes show strong linkages in the participants' travel needs and experience.

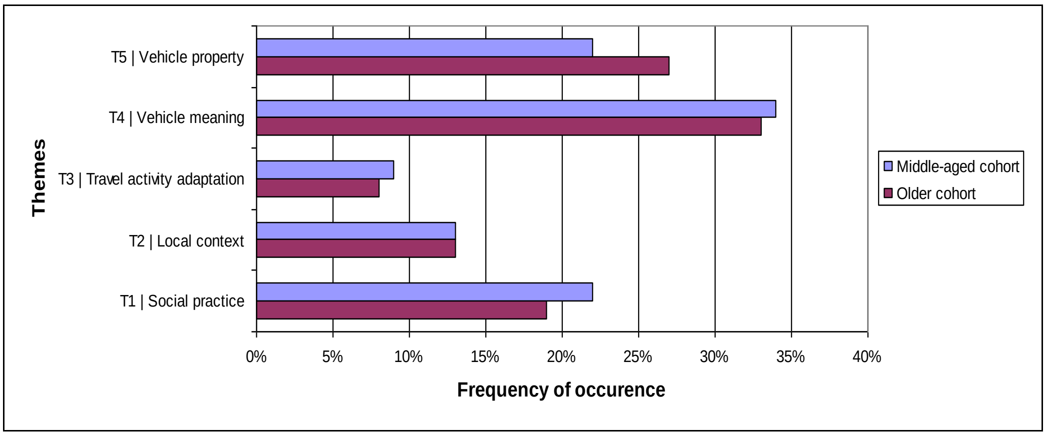

Figure 1 Theme comparisons between middle-aged and older cohorts.

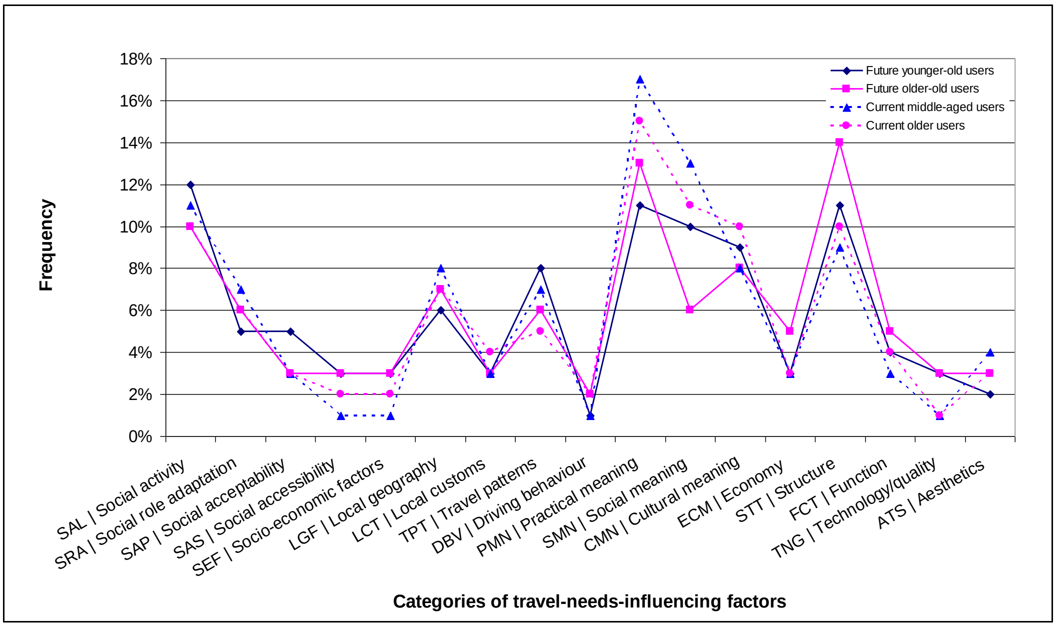

Figure 2 Integrated comparisons of travel-needs-influencing categories.

4.1 Social practice

Social practice plays an important role in explaining the investigated indicators of the aging population's mobility. It has been defined as a condition for the Chinese vehicle users travel experience. Social practice theme (Figure 3) involved social activity for maintaining daily lifestyle (SAL), social role adaptation (SRA), social acceptability (SAP), and social accessibility (SAS). The categories of social practices (SAL, SRA, SAP and SAS) show different patterns between the two age cohorts (Figure 2).

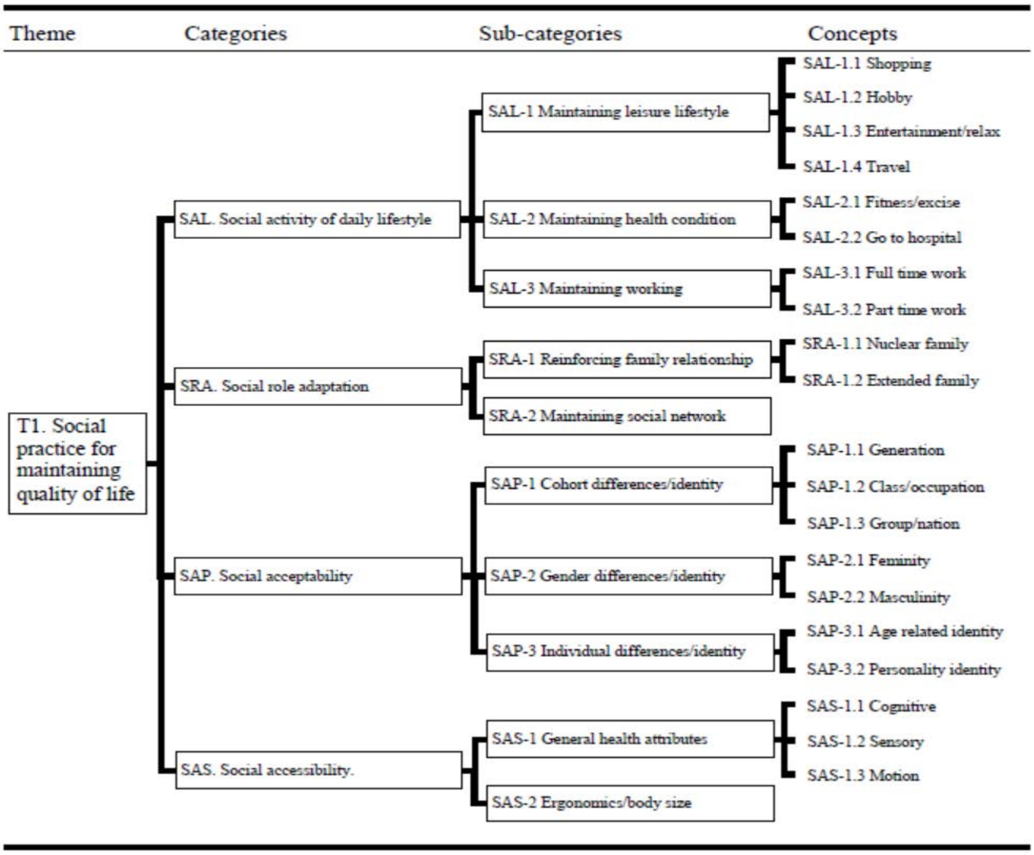

Figure 3 Social practice categories.

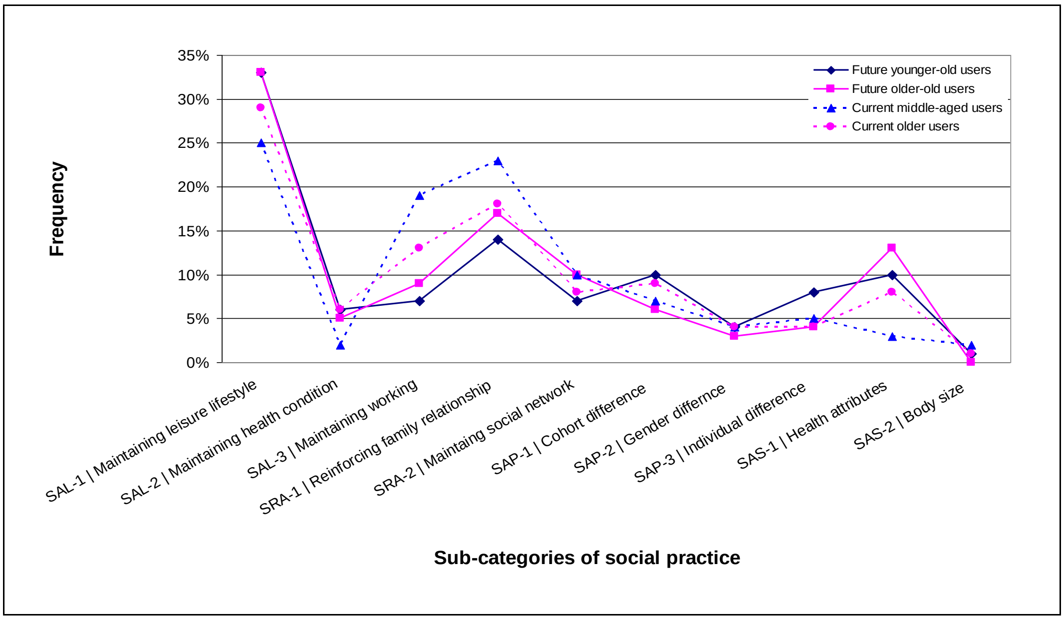

Figure 4 Integrated comparisons of social practice at the sub-category level.

Social activities for maintaining daily lifestyle encompass regular patterns of activity that represent habitual or customary behaviour and social affinities in daily life. The major sub-categories of social activity are maintaining leisure lifestyle (SAL-1), maintaining health condition (SAL-2) and maintaining working (SAL-3) (Figure 3). Social activities undertaken to maintain leisurely lifestyle (SAL-1) are one of the most frequently occurring types of activity within the social-practice theme (Figure 4). In the near future, the new older generation will retire and spend their savings on having a good time, which involves maintaining leisure pursuits such as shopping, hobbies, entertainment and travel (Figure 3). The future elderly vehicle users might travel more miles for maintaining their hobby due to lifestyle changes such as being retired from a full time job (Table 2). Travel to a leisure destination implies the transport of luggage and recreational equipment such as fishing tackle, camping equipment, pets and items for picnics. Such activities can be easily linked to the proper vehicle meanings such as the vehicle as a tool for carrying material objects (PMN-1.1) and a tool for exploring (PMN-1.7). Designers can also predict details of vehicle properties such as compatibility of vehicle capacity (STT-1) and food preparation accessories (STT-2) based on analysing users' activities and vehicle meanings.

Table 2 Statements on vehicle meaning and property supporting hobbies.

Participant	Statements
Participant 2:	My hobby is antique collecting. I would like to drive to the countryside or flea market to collect folk artworks and antiques when I am retired. So I need a vehicle which can not only carry these artworks but also protect these treasures when I am travelling in the countryside.

Social role adaptation can be defined as social position and responsibility adjustment combined with the aging process. Social role adaptation for reinforcing family relationships (SRA-1) is one of the most significant sub-categories which follow the social activity for maintaining a leisurely lifestyle (SAL-1) (Figure 4). The difference between future and current travel needs for both age cohorts has been identified at the concept level of adaptation for reinforcing family relationships (SRA-1). Both current and future aging generations pay more attention to the extended family (SRA-1.2) than the contemporary middle-aged people do. The concept of the extended family is important to vehicle design for the elderly Chinese users. The needs of extended family members such as grandchildren, oldest-old parents and distant relatives should be considered in the vehicle design stage. Using a vehicle to reinforce extended family relationships can be interpreted as tangible vehicle properties such as compatibility capacity for a gathering of relatives, childcare facility for grandchildren's safety, and emergency support accessories for oldest-old parents health care. Clearly, although culture as an intangible element in shaping the future aging generations' travel needs, it can be decoded as particular vehicle meanings and properties to support future aging generation's travel activities.

Social acceptability refers to the socially oriented benefits attained through ownership and experience with vehicle. Considerable differences emerged at the social acceptability category (SAP) between the two age cohorts. Future younger-old users emphasized social acceptability (SAP) more than current elderly and middle-aged people did (Figure 2). Clearly, future Chinese younger-old users seek self-identity through using vehicles within the global markets. Personal vehicles are important shapers of the self-identity in middle-age, and continue in later life as symbols of social acceptability for the future younger-old users. The Chinese vehicle users express their identity as a certain generation, class, group, gender or individual by the use of a personal car (Figure 3). This study shows that future elderly users are concerned about cohort identity (SAP-1) more frequently than they are at middle age (Figure 4). The Chinese users are group-oriented towards the social units with which interactions have been found (Yau, 1994). For instance, participant 5 in Table 3 shows that older Chinese vehicle users would like to take part in leisure activities by a particular group which is based on a similar hobby, early life experience and age cohort. Chinese elderly vehicle users prefer using 'we' rather than 'I' to describe the concept of self when they become old (Table 3: Participants 5 and 12), compared with using 'I' to emphasis personality during middle age (Table 3: Participant 4). This change with age, from self-identity to group-identity, matches different patterns between modern and traditional cultural values, which are hybrid within contemporary Chinese society. The elderly Chinese vehicle users defined and cultivated their individuality by using the personal vehicles that enable them to exist among certain groups. The local cultural elements play important roles in inspiring vehicle innovation by the use of appropriate form, colour, structure and function, in which multiple-status identity could be achieved.

Table 3 Statements on social acceptability of cohort identity.

Participant	Statements
Participant 5:	I will join a group composed of our generation when I retire. Members of such a group must have similar experiences, hobbies and income. We will drive our personal car and travel together.
Participant 12:	When we become older, our cohort's attitude must be different from the current 60's older people. We are more active than the current old generation.
Participant 4:	I enjoy being in a private car by myself. For my personality, I like to stay in a quiet and peaceful environment. This space is owned by myself. Nobody can disturb me when I sit in such a personal and independent small space.

The future new aging generations show more concern about their age-related differences from social and culture perspectives than from a *physical accessibility* perspective. This challenges earlier road safety research (Anstey, Wood, Lord, & Walker, 2005; Hakamies-Blomqvist, Siren, & Davidse, 2004) which highlights the age-related sensory and cognitive differences. Continuing driving in older age represented a significant way to ward off an 'old age identity'.

4.2 Vehicle meaning

Vehicle meaning allows designers to explore the manner and extent to which middle-aged and older vehicle users' past experience biases future use interactions. This study shows that vehicle meaning is one of the most significant categories (Figure 1). There are a total of 27 meanings given by Chinese vehicle users related to their current and future travel needs. These are categorized in three core groups: practical meaning, social meaning and cultural meaning (Figure 5). Significant differences between the two age cohorts emerged at practical and social meanings (Figure 2).

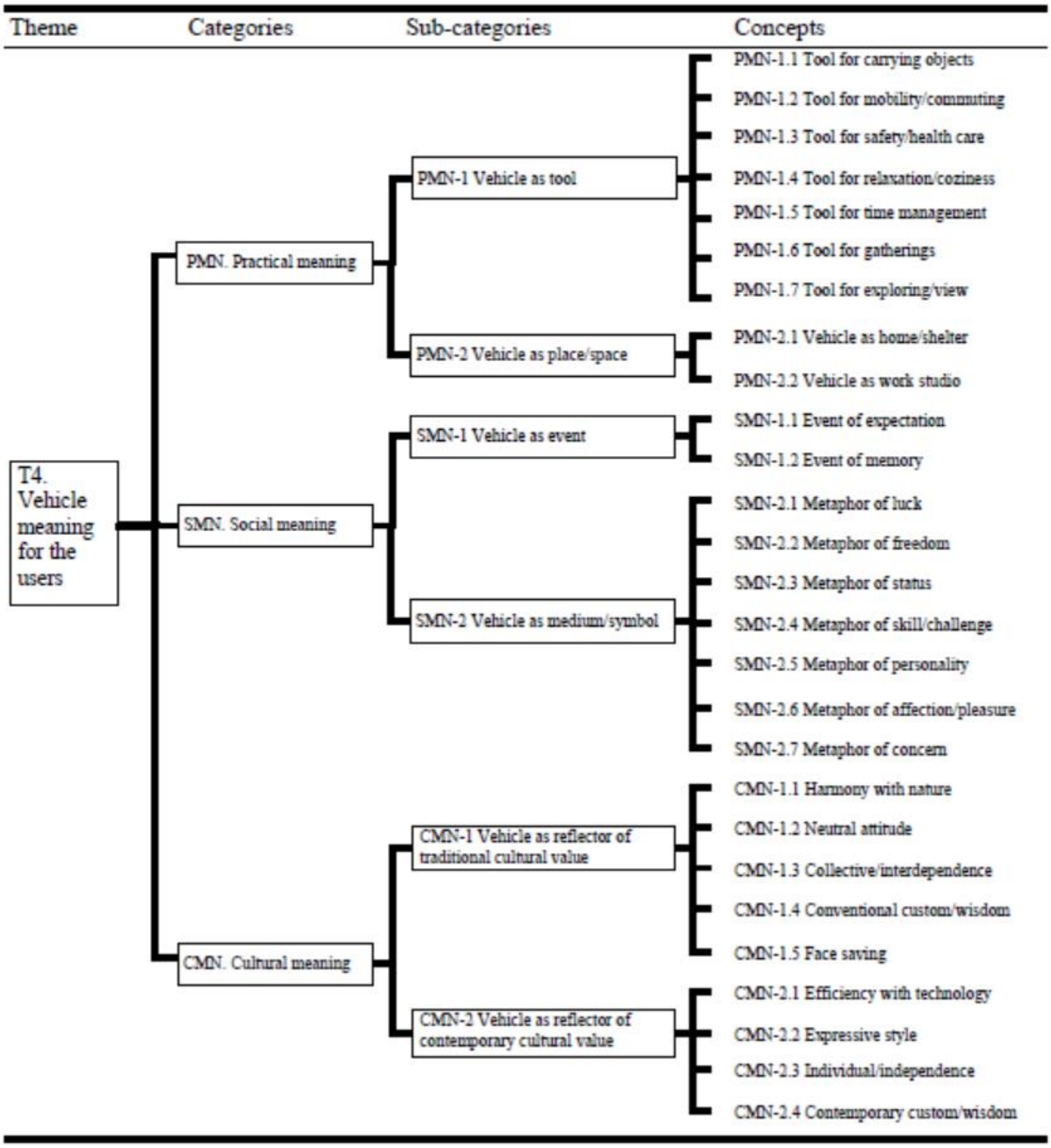

Figure 5 Vehicle meaning categories.

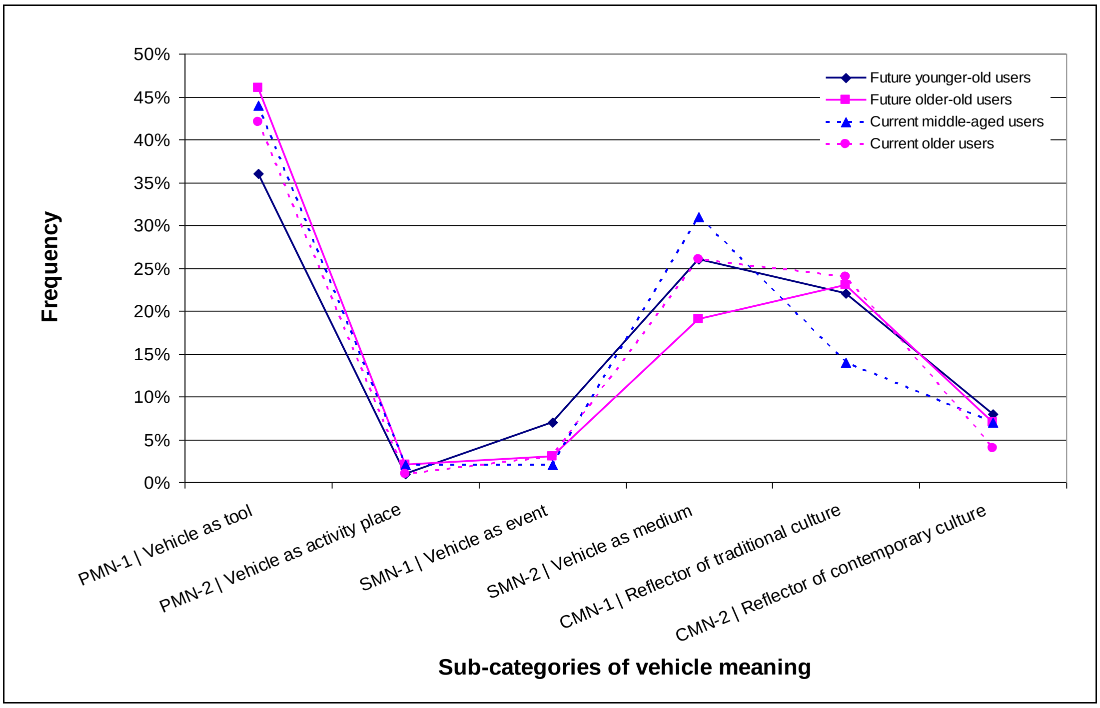

Figure 6 Integrated comparisons of vehicle meaning at sub-category level.

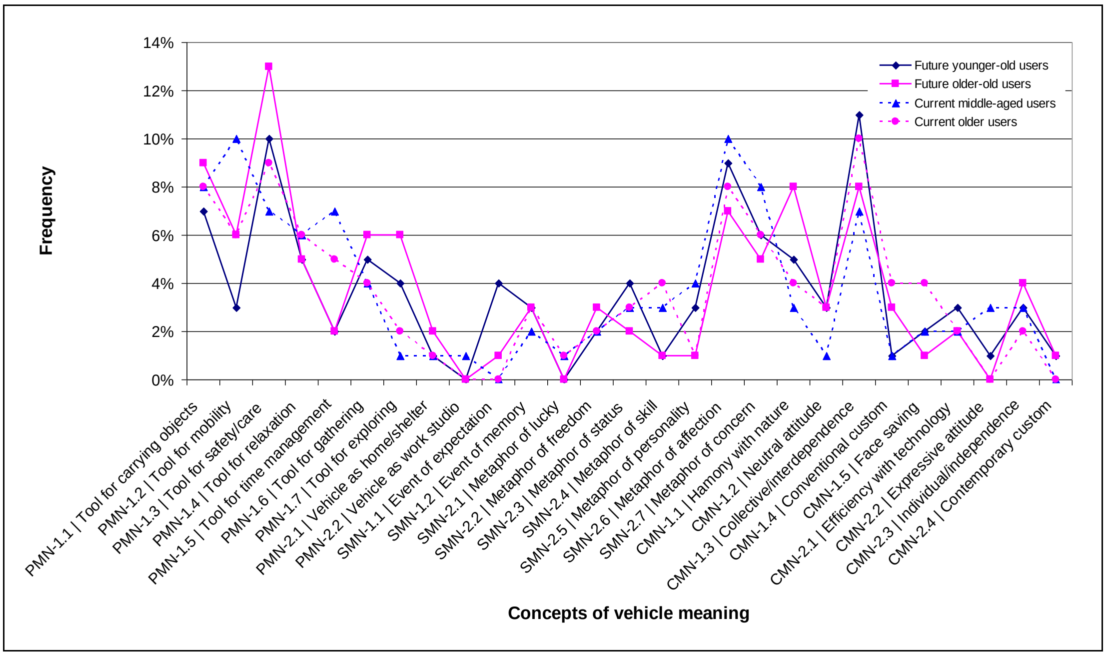

Figure 7 Integrated comparisons of vehicle meaning at concept level.

Practical meaning is intimately tied to the product's physical attributes and benefits, and the inherent need satisfaction these provide. The middle-aged cohort was concerned about practical meaning more currently and less in the future than the elderly cohort was. Future younger-old users mentioned the practical meaning least frequently (Figure 2). Practical meaning can be divided into two sub-categories: vehicle as tool (PMN-1) and vehicle as activity place (PMN-2). Figure 6 shows that the vehicle as a tool (PMN-1) is most frequently mentioned by both age cohorts.

There are many differences patterns that emerged at the concepts of vehicle as tool (PMN-1) between two age cohorts (Figure 7). The data suggest that the vehicle as a tool for time management had different meanings, which include the efficient use of time, saving time, reordering time and killing time. For example, the vehicle as time management was often related to the efficient use of time by switching a time consuming or boring activity to a different meaningful activity niche (Table 4). It is clear that reinforcing family relationships (SRA-1) is an important condition for leading Chinese future older generations to adapt their travel activities (child education escort). This particular activity was based on the Chinese collective (family) cultural value, and generated the specific vehicle meaning (tool for time management), which might guide the design of new vehicle properties such as entertainment support accessories and working support facilities. In addition, both age cohorts had similar attitudes toward the vehicle as a tool for social gatherings (PMN-1.6) (Figure 7). This attitude is rooted in Chinese collective culture values (cultural meaning) and associates with social role adaptations (maintaining social network), local customs (social ritual), travel patterns (travel by group), social meanings (metaphor of concern), and vehicle framework (compatibility capacity).

Table 4 Statements on practical meaning.

Participant	Statements
Participant 12:	I need to drive to take my son to study karate on Thursday evenings. I have to wait for him in the car for two hours. It is so boring and wastes time. So, I read a book or keep working in the car. Actually, it is hard to keep reading due to the weak light in the car. It is also hard to use a laptop in my car, due to the small space and inadequate in-vehicle accessories… My next car should solve these problems because I will escort my grandson to school as well when I retire.

Social meaning of the vehicle involved two categories: vehicle as event (SMN-1) and vehicle as medium/symbol (SMN-2) (Figure 5). Artefacts can be defined as social agents in the limited sense that they extend user activity and mediate social meanings between users (Dant, 1999). In this study, social meaning (SMN) category shows one of the most skewed distributions by age. Figure 2 illustrates that 13 per cent of current middle-aged users mentioned social meaning versus 10 per cent of future younger-old users and only 6 per cent of future older-old users. It is clear that future new aging generations highlighted social meaning significantly more often than the current elderly.

Figure 6 illustrates that the vehicle as medium/symbol (SMN-2) was considered as more important than the vehicle as event (SMN-1) for both age cohorts. The vehicle's symbolic meaning declines from the middle-aged cohort to the older cohort. The different patterns are emerged between two age cohorts at the concepts level of symbolic meaning. Firstly, the vehicle as metaphor of luck (SMN-2.1) is identified as a stable factor for the both age cohorts. The representative examples of the luck metaphor are the decorations of auspicious symbols that are placed in different parts of the vehicle space. For example, the right-hand picture in the Figure 8 illustrates the typical location of lucky symbols, which are usually hung below the inner rear mirror. Some vehicle users put a traditional talisman, such as a tiger, in the back of the vehicle to avoid a rear-end crash (the left-hand picture in Figure 8). Relying on superstitious power for protection is rooted in traditional Chinese cultural values (LCT). Designing vehicles for the safety need is related not only to the use of technology to extend elderly drivers' physical capabilities, but also to the employment of proper lucky symbols to reinforce older people's safety-related spirituality and confidence. Secondly, Future younger-old users were more concerned about the vehicle as a metaphor of status (SMN-2.3) than were the future older-old users. Thirdly, the vehicle as metaphor of affection/pleasure (SMN-2.6) is broadly related to other categories. For example, Participant 23 (Table 5) claimed that the vehicle model plays an important role in shaping the female users' gender identity (SAP-2.1) and further influences her affection (SMN-2.6).

Figure 8 Auspicious symbols as representative on vehicle as metaphor of luck.

Table 5 Statements on social meaning of the vehicle.

Participant	Statement
Participant 4:	I remember how hard it was when I sold my old car. I felt so depressed when I had to give the car's keys to other people. It was like my kid, and it had been with me for six years. I drove it and carried my family and friends. It contains a lot of stories and memories. For a man, his car contains a particular affection.
Participant 23:	I love the streamlined model. It is so beautiful. As a woman, I like a car that is fashionable and beautiful.

This study shows that meaning referring to the past (SMN-1.2) increases from the middle-aged to the elderly (Figure 7). The vehicle is a sign of past events, of ties to family, to other people and to emotional experiences for the older Chinese users. Vehicle designers have to know the history and past experience of the future younger-old users. Participant 4 in Table

5 shows that the vehicle's social meanings derive from the user's memories of the occasions on which the vehicle was a tool for personal mobility (PMN-1.2), the metaphor of concern in a social network (SMN-2.7), the moment of intimacy over the years in which one may have expressed to a friend, one's appreciation of this object. Clearly, the vehicle as event is closely associated with the vehicle as metaphor of affection. The design features such as shape and colour serve the physical medium to contain or express these kinds of meanings.

Cultural meaning is made a visible, demonstrable part of the material world through interactions between users and vehicles. This study shows that vehicles have a significance that goes beyond their functional character and social value. This significance has its roots largely in their ability to carry and communicate cultural meanings (McCracken, 1986). The data suggest the duality of dimensions of cultural meaning, which comprises traditional and contemporary sub-categories and concepts (Figure 5). Compared with practical and social meanings, cultural meaning presents a more-stable pattern than the others in that both age cohorts present similar frequency of this category (Figure 2).

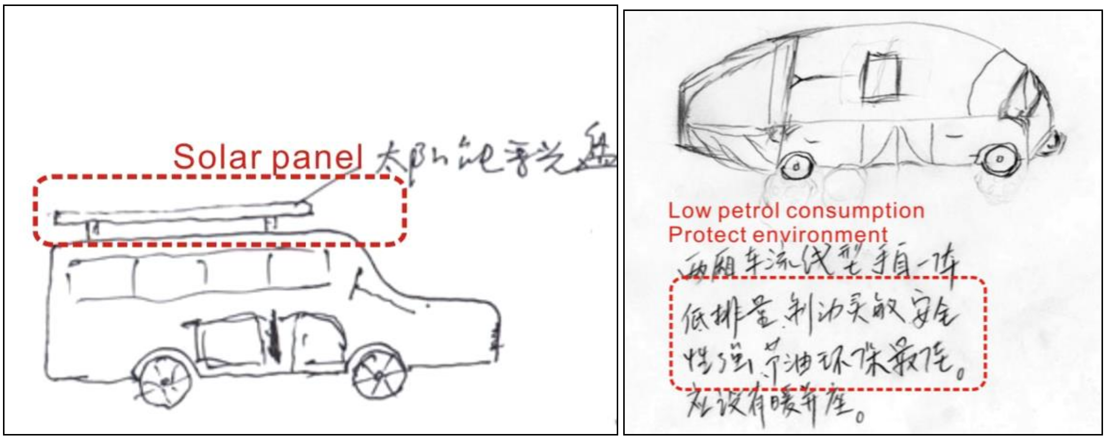

Figure 9 Participants' sketches of vehicles as a reflector of harmony with nature.

The vehicle as a reflector of traditional cultural values (CMN-1) has been identified as one of the most significant sub-categories (Figure 6). The aging population are concerned about traditional cultural values more than the current middle-aged users. Firstly, the vehicle as a reflector of collective cultural values (CMN-1.3) has been identified as one of the most significant concepts and the aging populations paid more attention to this concept than the current middle-aged people (Figure 7). In Chinese culture, people are integrated into strong cohesive in-groups and individuals act predominantly as members of a group (Hofstede, 1997). Moreover, collective cultural meaning is broadly embedded in other major themes such as social practice, travel activity and local context. The data (Table 6) show that collective cultural meaning can be observed by older people's activities such as gatherings of extended family members and social networks (SRA and PMN), celebrating traditional festivals (LCT) and travelling in groups (TPT). It also can be interpreted within the compatibility vehicle framework and food preparation accessories, which provide tangible properties to support vehicle users' collective social activities within the Chinese cultural context. Designing vehicles for the elderly users should focus on collaborative activity, should highlight reliability and quality, and should imagine groups of people using the vehicle. Secondly, concept of harmony with nature (CMN-1.1) can be interpreted by the sustainable transport demands and environmentally 'green' travel behaviour. The new technology (TNG) is not only assisting elderly users to reduce petrol consumption (ECM), but is also reshaping the vehicle's appearance. For example, in the left-hand picture of Figure 9, the elderly user has drawn a large sustainable-technology device (a solar panel on top) which dominates the profile of his new vehicle. Such original sketches (Figure 9) generated by elderly users can give designers valuable inspiration in designing the next generation of sustainable transportation for the future aging population.

Table 6 Statements on vehicle as reflector of collective cultural value.

Participant	Statements
Participant 34:	I enjoy organising an elderly Chinese opera club. The members are elderly people like me. I use my car to carry these elderly fans and instruments to participate in some community performance, especially during the traditional festivals.
Participant 12:	I need a big camping car. A group of people… they probably drive several camping cars to travel together. At the destination, these camping cars make a circular space that looks like a Chinese yard. We can celebrate the Chinese new year in this yard, cooking and eating together, playing games together, and helping each other…you know, my family, my friends, a group of people…

4.3 Vehicle property

The vehicle property theme refers to a vehicle's physical attributes such as economy (ECM), structure (STT), function (FCT), technology (TNG) and aesthetics (ATS). Designers of transportation need to have details about physical vehicle properties from users' perspectives. However, this study found that vehicle users cannot exactly identify the kind of vehicle properties — such as form, colour and function — they want because they do not have professional design knowledge. They can only explain what kind of the lifestyle they want, how they perceive their vehicle, and how they want to use their personal vehicle in the future. Therefore, although overall statistics show that the vehicle property theme is mentioned by the participants frequently (Figure 1), it is hard to get useful information to guide design innovation from the ambiguous and general verbal protocols. Vehicle innovation for the local elderly users might systematically study the user–vehicle interaction rather than focus on the products properties in isolation.

Vehicle structure (STT) category demonstrates that current automobiles designed for universal global markets cannot fulfil the Chinese vehicle users' culture-specific travel needs. Local users can only adapt their current personal vehicles through changing some minor accessories to fulfil the unmet needs because it is impossible to do the framework changes for their current cars by themselves. However, when local users talked about the next car they wanted to buy, they needed the new generation vehicles which will be designed totally based on their particular travel needs. That is, vehicle innovation is related to not only accessory adaptations, but also to revolutions in structure. The major elderly user's consideration was the vehicle's physical compatibility with different things stored inside and with different abilities of the people seated inside. The appropriateness to elderly users' activity such as adaptation social role (SRA-1) for caring of oldest-old parents (SMN-2), and transporting objects (PMN-1) for leisure lifestyle (SAL-1) emerges as another way of defining compatibility. In the users' sketches, these factors become explicit by the tall vehicle roof, well-matched boot, flexible-adjustment seats, and travel-related devices.

Technology category shows a constant characteristic (Figure 2). Although prior research (Fisk, Rogers, Charness, Czaja, & Sharit, 2004) claims that old people were more ready to transfer their anxiousness to new technology, this study shows that the future younger-old generation wishes to use smart technology to extend their driving ability and to ensure their driving safety. The future elderly often mentioned assistive technology devices such as GPS, audio warning systems, auto transmissions, in-vehicle internet, automatic car locks and energy saving systems. Such smart technologies are closely related to the vehicle accessories adaptation (STT), and vehicle function innovations (FCT) to reshape a vehicle's practical, social and cultural meanings.

4.4 Local context

The local context theme includes socio-economic factors (SEF), local geography (LGF) and local customs (LCT). Under socio-economic factors, this study groups general economy factors and national regulation factors. Under local geography are grouped residential patterns, travel resource and local climate. The local customs category comprises beliefs/philosophy and social ritual sub-categories. Compared with the social practice theme, which constructs Chinese subjective culture, local context shapes Chinese objective culture (Stewart & Bennett, 1991). Middle-aged and elderly cohorts present similar frequency among the local context categories and sub-categories.

The data suggest that most leisure travel demands rest on underlying *local geography* (LGF) and cultural tensions, particularly where the countryside and heritage are concerned by elderly vehicle users. Therefore, considering the traffic infrastructure and road conditions in the Chinese countryside, future older users' vehicles might have reliable quality, solid form, and off-road functions to support leisure travelling to the countryside.

Local custom (LCT) shows the stable characteristic in this study. Within the local custom category, the concept of social ethics can be easily linked to social role adaptation for reinforcing the family relationship category (SRA-1). For example, the filial piety doctrine, which is primary a Chinese ethical principle, drives the younger-old user to use a car to take care the oldest-old parents. The festivals in China strengthen familial bonds which involve family reunions and ancestral worship. Chinese older people organize various travel-related activities to celebrate festivals to help younger generations gain a deeper understanding of their own roots. Therefore, they look on the personal car as a tool to gather the family members within this cultural context.

4.5 Travel activity adaptation

This study emphasises using context-dependent heuristics to explore the travel activity and travel needs. Figure 1 illustrates that both age cohorts mentioned the travel activity adaptation theme (T3) least frequently comparing with other themes. This finding demonstrates that there are considerable limitations if research only focuses on the travel behaviour per se. Vehicle design research should look into travel activities that relate to conditions such as social practice and local context, and to consequences such as vehicle meanings and properties.

Travel patterns (TPT) have close relationships with social activity (SAT) to shape a vehicle's practical meaning (PMN). This study demonstrates that car dependence is a significant characteristic of the future younger-old generation. The elderly Chinese people reliant on public transport have considerable difficulties accessing facilities and maintaining social contacts. Regular public transport services in China are of limited utility. Since future older generations often leave the city centre for leisure purposes (SAL-1), the vehicle is a frequently used means of exploring (PMN-1.7). The vehicle should be designed to afford long-distance and long-time journeys for the elderly users. To achieve this aim, designers need not only to understand the users' age-related cognitive and physical changes, but also to research older users' trip-related activities and contexts.

5. Discussion: structuring and interrelating categories

This study provided evidence that different meanings of vehicles and activities of the older users closely affect the vehicle design for a local market, not only with regard to the experience of the older users, but also with respect to the transfer of these connotations to the innovation and evaluation of the vehicle. Correlative analyses were used to identify the main covariates (Helfenstein, 2005) that were needed to establish the interrelationships among the elderly users' experience, vehicle meanings and vehicle properties. By associating core categories that emerged from analysis, this study argues that practical meanings link with vehicle structure more densely, and social meanings associate with aesthetics more frequently. Meanwhile, cultural meanings present stable characteristics because variables within the cultural meanings are evenly distributed among the different vehicle properties.

The complex symbol systems such as form, feature and colour give rise to metaphor, grammar, and semantics for vehicle design. The interactions between older users and vehicles also construct these symbolic systems which reflect a particular subjective culture. Therefore, this study argues that vehicle designing should go beyond the surface level of the objective cultural system. Designers should integrate the objective culture, which is embedded in the local context, and the subjective culture, which is embedded in the social practice. It is essential for the human-centred design approach to explore this macro-level of context because characteristics of elderly users' needs variables firmly depend on changes of social practice and local context.

This study develops a conceptual model which suggests an approach for the collection and structuring of user information during the vehicle design process (Figure 10). Through examining the data from the perspective of their influence on elderly users' needs, designers will easily be able to relate the data to vehicle properties as defined by older users themselves. In the users' domain, understanding the objective and subjective cultural contexts helps predict future younger-old vehicle users' needs. The variables within the social practice and local context drive the future elderly users' travel activity adaptations. The *cultural elements* play an important role in integrating these categories. In the vehicle domain, to fulfil the future younger-old users' needs, the *technology* drives the intangible and tangible attributes such as economy, structure, function, and aesthetics to shape physical vehicle properties. The vehicle meanings generated by the interaction between the vehicle domain and the older users' domain help designers to better understand the relationships among the properties, and the experiences that they provide. Such understanding in depth helps designers to identify the details of elderly users' needs. The overall interactions among the older users' domain, the vehicle domain and the vehicle meaning construct the design performance domain, which is driven by multiple dynamics such as *culture*, *technology* and *experience*.

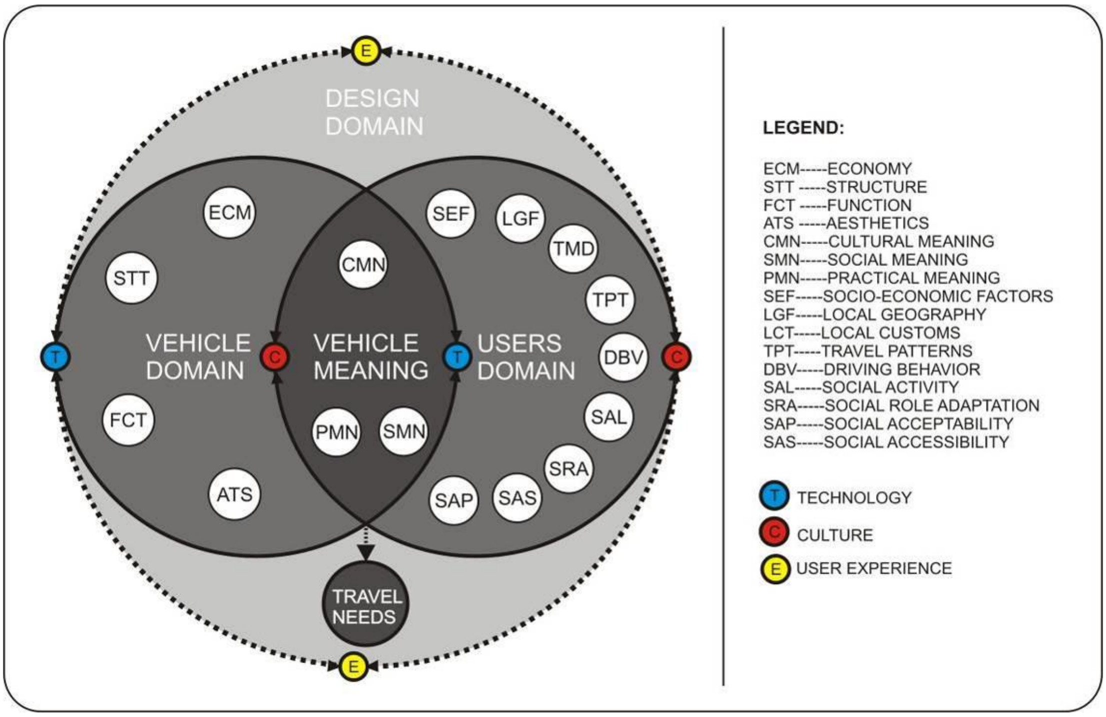

Figure 10 The conceptual model for structuring user information.

Designers expect that potential users have some preconception and attitude toward their products, and their use at the initial interaction with artefacts (Helfenstein, 2005). Users carry over such experience-based information contents to novel interactions with artefacts.

The older vehicle users' *experiences* involve not only *cultural context*, but also *technological factors* when they interact with motor vehicles. These contents will affect both physiological and psychological representations that future older users construct of interactions between vehicles and themselves, in which certain vehicle meanings are generated. The designed vehicles are the media that provide these experiences. On the other hand, such experiences help to define the contemporary and traditional Chinese cultures, and indeed to redefine the future younger-old vehicle users and provide them with meaning.

All in all, Figure 10 attempts to demonstrate the dynamic factors for the future older Chinese vehicle users: *culture, technology* and *experience*. Vehicle design can be defined as a cultural production and technology adaptation system to construct the future older users' experience. The concept of experience for the future younger-old users is essential as a unifying issue between the culture and technology of design, as a means of understanding the context of vehicle design, and as dynamic factors to inspire design thinking. Therefore, this conceptual model has integrated the structures of all categories generated by this research. It suggests how these categories relate to each other and how design activity synthesizes them logically. This theoretical model provides a framework for identifying a boundary between a coherent body of knowledge specific to designing and the body of knowledge related to other disciplines. That is, it develops a theory on the interactions involving human (older users), objects (vehicles), and contexts (Chinese social and cultural contexts) together.

6. Conclusion and recommendations for further study

This study provided evidence that different meanings of vehicles and activities of the older users closely affect the vehicle design for a local market, not only with regard to the In this study, the travel-needs-influencing factors between middle-aged and elderly Chinese vehicle users are systematically compared. Vehicle meaning is identified as the most significant theme for both age cohorts. Meanwhile, local contexts show constant characteristics for the Chinese participants. The interpretations of older Chinese users' travel-needs-influencing factors suggest that most categories have implicit or explicit relationships associated with others. Culture, technology, and older users' experience play the dynamic roles to drive design innovation for the future aging generation. Designing meaningful vehicle can be defined as a cultural production and technology adaptation system to construct the future older users' experience. The application of the model will focuses on designing meaningful concept vehicle for the older Chinese users as a representative example. Based on understanding the theoretical model generated by this study, designers will design concept vehicle for the Chinese future older drivers. The concept of vehicle design as outcome of further research will serve as a bridge between theoretical research and design practice.

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Towards Innovative and Inclusive Architecture

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Abstract: Acknowledging that the Danish Buildings Regulations is having an impact on the design of inclusive architecture, a Danish government agency focuses on new models for the accessibility requirements in the future Building Regulations supporting an innovative and inclusive architecture. In order to establish empirical material for the analysis and development of new models, architectural firms have been invited to workshops and group interviews to present their own experience of the challenges and the opportunities that they meet in their everyday practice as users of the Buildings Regulations. The prescriptive accessibility requirements were criticised for being too homogenous. A majority of the firms suggest a performance-based model in order to work with 'accessibility zoning' achieving flexibility because of different levels of accessibility in a building due to its performance. Paradoxically a minimum level is required in order not to lose accessibility.

Keywords: Design practice; inclusive design; accessibility; performance-based codes

1. Context

In a Danish context, accessibility is associated with the Danish Building Regulations. They play a role in the design practice just as the regulatory framework and architectural design are related in a complex network consisting of different actors. In order to understand this relationship knowledge is needed (Imrie & Street, 2011).

A Belgian study shows that the approach to accessibility varies from firm to firm (Wauters, Vermeersch, & Heylighen, 2014). A Danish study of 11 architectural firms, used to work with accessibility and inclusive design, supports these findings showing that one firm thinks of accessibility from day one while another one prefers to work with equality as a design parameter in order to structure their design process (Kirkeby, 2015).

Do we know anything about how do the actors of the building process experience the Building Regulations? In Norway, requirements to accessibility and inclusive design in housing are regarded as constraining the opportunities for creating architectural design of high quality because they are too strict (NAL, 2014). In Denmark, interviews with the actors of five projects showed certain reservations. It is not a reservation that concerns the accessibility requirements as such, but a few of them and the fact that they should be followed everywhere in a building. Some of the developers have reservations regarding the economy and want to prioritise between the requirements. Reservations occur when architects experience that the requirements can have a negative influence on the architectural quality and their own freedom to create a specific architectural expression. Furthermore, professionals experience that the focus on accessibility in the processing of building permits, issued by the local building authority, differs from municipality to municipality (Frandsen, Kirkeby, Ryhl, & Pedersen, 2012).

This difference was also experienced among architectural firms in another Danish study based on interviews with 10 architectural firms about how to ensure that the architectural designs comply with the requirements. In addition, one of the architects states that there is no room for the architectural firms to investigate, whether it is possible to create better designs because of the local building authority. Others suggested dialogue “star-meeting” with the local building authority and the professional representing the different specialties in the beginning of the process (Grangaard & Ginnerup, 2014). A previous dialogue with the local building authority offered by the Building Act is often seen in Scandinavia (Grangaard & Ginnerup, 2013). The possibility of addressing accessibility in the previous dialogue in Norway was rarely realised because the local building authority did not consider it necessary since accessibility was already a part of the Norwegian building regulations (Nørve & Øyen, 2004).

In 2013, the Danish Government launched a disability policy action plan 2013 ‘A Society for All’. In this handicap action plan, it is described that despite the clear and ambitious accessibility requirements in the Danish Building Regulations, it is a challenge to ensure the interplay between the requirements and the most recent technologies and solutions in the building sector in order to develop innovative and flexible design.

The Danish Transport and Construction Agency was aware of an interest in another model because a pilot project involving a group of persons with disabilities and a group of experienced architects and landscape architects within the field of accessibility and inclusive design revealed an interest in performance-based codes. Furthermore, the groups point out a growing need for knowledge and insight in the field of inclusive design supposing a new model for the requirements was implemented (Kirkeby, Ryhl, & Frandsen, 2014).

The project “An analysis of the accessibility requirements” was therefore commissioned by the Danish Transport and Construction Agency. The project studies which barriers the building sector in Denmark – primarily the architectural firms - meets in their everyday practice working with accessibility and inclusive design. Furthermore the involved professionals are encouraged to contribute with their input about new models for regulation. It is a general term for the project that the level of accessibility should not be reduced.

Based on the project "An analysis of the accessibility requirements", this paper presents the future model for Building Regulations which the professionals regard as a tool for supporting the design of innovative and inclusive architecture.

2. Theory

Traditionally accessibility has been used as concepts in the Danish context while the concept of Universal Design has not yet been applied (Ryhl, 2012; Ryhl, 2009). Despite the fact that Universal Design as a concept is central to the UN Convention on the Rights of Persons with Disabilities, it has not been absorbed in the architectural field. In this paper, inclusive design is used as a united term for universal design (Mace, 1985), design for all (Bendixen & Benktzon, 2015) and inclusive design (Clarkson, Coleman, Keates, & Lebbon, 2003). Accessibility is regarded as a part of inclusive design.

In Denmark, the requirements to accessibility were applied to the Building Regulations in 1972 and tightened in 1977, 1995 (BR95) and 2008 (BR 08). The Building Regulations is traditionally based on prescriptive requirements, but over the years it has been formulated much more as performance-based requirements except in the case of requirements to accessibility.

In 2004, the performance-based fire codes were introduced because the traditional prescriptive requirements were becoming obsolete - tangible but also very rigid and primitive. Limited theoretical knowledge about among other things fire behaviour was the main reason for the survival of the prescriptive fire requirements in the Danish Building Regulations. When designing buildings appropriately for their use, the prescriptive fire requirements can be considered an obstacle. With performance as the basis for the new codes, it was the purpose to achieve a more flexible way of regulating and supporting flexibility and innovation in the building design. It is now possible to design e.g. open spaces and evacuation routes differently. The new field of fire-safety engineering has emerged as a result of the performance-based codes. Fire-safety engineering is about analysis and documentation of the fire safety of a building and therefore fire-safety-engineering is interrelated with the performance-based codes (Schiøtt Sørensen, 2014). In the field of energy consumption, the Danish Building Regulations operates with the energy performance framework which covers the total demand for energy supply in buildings. This model makes it possible to insulate in non-identical ways everywhere in the design, but to calculate the average energy consumption inside the framework.

Kirkeby distinguishes between context-independent knowledge and context-dependent knowledge in the making of architecture. The context-independent knowledge seen as building regulation and guidelines is criticised for being too prescriptive by architects used to working with accessibility or inclusive design. Especially in the first phase of a design process, it is the context-dependent knowledge that inspires the design but later in the process context-independent knowledge is used as a tool for quality control (Kirkeby, 2015).

3. Methods

The empirical material reported in this paper was derived from regional workshops and group interviews with Danish architectural firms in the project “An analysis of the accessibility requirements”, a project which aimed at analysing and developing new models for future building regulations based on input from their daily users.

It was the intention to capture the challenges of everyday practice in relation to the accessibility requirements in the Building Regulations but there was no funding for a huge ethnographic fieldwork at the drawing table in different architectural firms like Cuff did (Cuff, 1991). The research design aims at coming as close to the practice as possible while at the same time involving as many professionals as possible from a user-centred perspective.

Every architectural firm in Denmark had the opportunity to be involved. Thus all the 700 members (architectural firms and landscape architectural firms) of the Danish Association of Architectural Firms plus a number of engineering companies were invited to workshops in different parts of Denmark. The 98 Danish municipalities were invited because we also wanted to involve the employees actually occupied with architectural design in the municipalities.

64 professionals were enrolled in the workshops for architectural firms and other building consultants representing 51 firms, but only 48 participated representing 41 firms. 23 employees from 15 municipalities were enrolled in the workshops, but only 20 of them did participate representing departments in 12 municipalities. The workshop groups were a mix of architects, landscape architects, construction managers and engineers.

Eight group interviews were conducted with architectural firms. It was the intention to involve highly esteemed architectural firms but in contrast with Kirkeby´s interviews (Kirkeby, 2015), none of the firms were recognised because of their work with inclusive design. Another criterion was to obtain a representation of different sizes and categories of building designs; culture, education, administration, hospitals, housing and care homes. The size of the firms varied from 19 to 278 employees. In this paper, they are named A19 – A278.

The approach to the workshops and the group interviews were qualitative in order to establish an understanding of the everyday practice. In order to facilitate reflection on own practice and to document specific experience in every group interview, the architectural firms were asked to select two realized projects; two cases that we visited and analysed in advance. It was not important for us to detect whether the requirements of the Danish Building Regulations had been followed, but rather we were curious about the mind-set and the concept behind the designs.

The workshops were structured around the challenges, possibilities and future models when aiming at an inclusive architecture of high quality. The group interviews were semi-structured. We asked how they work with inclusive design. Because we wanted to address other aspects of inclusive design than traditional accessibility, the interview guide consisted of questions about the users and quality of use (Høyland, Denizou, Woods& Christophersen, 2012), wayfinding and sensory accessibility (Ryhl, 2009a). Photos from the cases were presented in order to create a physical common frame of reference. Finally, a reflection on future models was initiated.

Between one and nine professionals participated in each interview; architects, landscape architects and construction managers. One or two members of the management participated in four of the interviews.

Each workshop lasted three hours and each group interview lasted two hours. Both workshops and interviews were tape-recorded and transcribed. The author has translated the relevant quotes from Danish to English.

4. The findings: a performance-based model

The participants distinguished between design of new buildings and alteration/renovation envisaging new models. A majority of the workshop-participants and the interviewed firms suggested a performance-based model known from the field of fire-safety but inspired by the energy-performance framework in the Danish Building Regulations in order to support innovation and architectural quality in the design of new buildings. Different aspects related to their practice and this future model like strategy, dialogue with the client, architectural competition, design-build contract, knowledge and examples were presented. In this paper, the focus is on the model of an accessibility performance-based model, and the argument for this model.

Initially the broadness of views by the group interviews on a performance-based approach to regulation of accessibility is presented. The arguments regarding zoning and differentiation for a new model are subsequently presented followed by input about a minimum level and the quality of the building control due to a new model.

4.1 Positions

In the interviews, the firms were asked to reflect on the actual situation in their two cases if the accessibility requirements had been performance-based. The eight firms represented a broadness of positions.

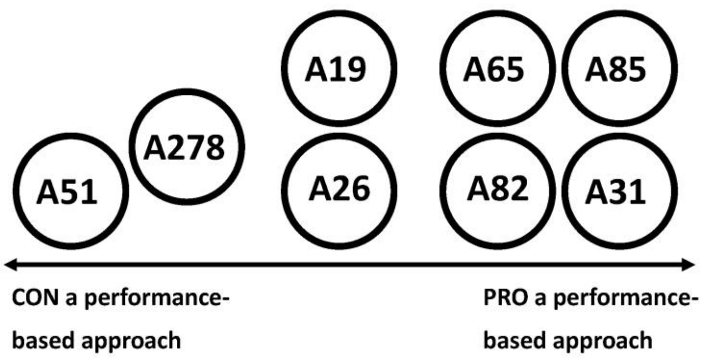

Figure 1 Different positions of a performance-based approach among the eight group interviews.

Three (A31, A82 and A85) of the architectural firms envisaged that a performance-based model would have changed the design of the two cases. One firm (A65) found that in one of the cases they had worked with the accessibility to such a degree that a model would only have affected the other case. The motive is the creation of options and room for manoeuvring in order to support the architectural quality of every design project.

> "The feeling of having a palette so you can choose what is right for the project instead of having to hit a specific target using a specific requirement whether it is right or not for the projects as a whole or for the users or for the client" (Group interview with A82)

Two firms (A19 + A26) were not sure about an actual difference because they believed that they had got used to the requirements and found ways to comply with them. But at the same time, they were intrigued by this model. Two firms (A51+A278) did not think that a function-based model would have made any noticeable difference to the two cases. The firm A278 pointed out that they had worked together with an accessibility advisor in one of the cases. For them a design-build contract was a greater challenge than the Building Regulations. A51 would not complicate the requirements unnecessarily with a new model.

> "… how difficult can it be. Well, there aren´t many pages about accessibility in the Building Regulations. It is something with some threshold, some heights and some ramps, well…" (Group interview with A51)

Among the majority of the firms, there is a clear idea about a new model supporting their work practice.

4.2 A request for differentiation and zoning

Especially among the interviewed firms there was a huge interest in a possibility for differentiation. The existing prescriptive accessibility requirements of the Building Regulations were criticised for being too homogeneous and for being unreasonable. Hence the performance-based approach was seen as a way of dealing with these barriers.

It was regarded as an absurdity that the same requirements were applied to different types of buildings and sizes of buildings and for that reason the homogeneity of the accessibility requirements was problematised.

That the Building Regulations requires level access at all external doors, e.g. from an apartment to a balcony in a building without a lift, was mentioned as unreasonable in nearly all the workshops and group interviews. It was exemplified in different variations as a result of the interplay with other parts of regulation particularly in relation to roof terraces.

One problematic aspect was whether the requirements had the consequence that a terrace was deselected which should have added quality to the building.

> ”- The requirements can limit the potentials of a building. (…)
>
> - Then all people should have the option and not these 10 % or 1 % who shouldn´t have the option to participate.

- No, I agree. But I think the problem occurs when a client prefer to go without a roof terrace. Then you can say that we exclude 100 % from this option." (Dialogue between two participants of a workshop)

A lift to the roof terrace created another triggering challenge in the category of unreasonableness due to the interplay with other regulations; calculation of open spaces (a lift takes up too much room) and the district plan made by the specific municipality, which did not allow the lift towers to be too conspicuous.

> "In this building complex one roof terrace is very small about 30-40 square meters but should be included in the calculation of open spaces. But this roof terrace can only be included if there is a lift to it regardless of that there is a lift to the other two roof terraces. Some wheelchair user should in reality be offered access to all levels. But it would perhaps have made sense if it had been possible to deselect and say that this particular terrace is not accessible."(Group interview with A51)

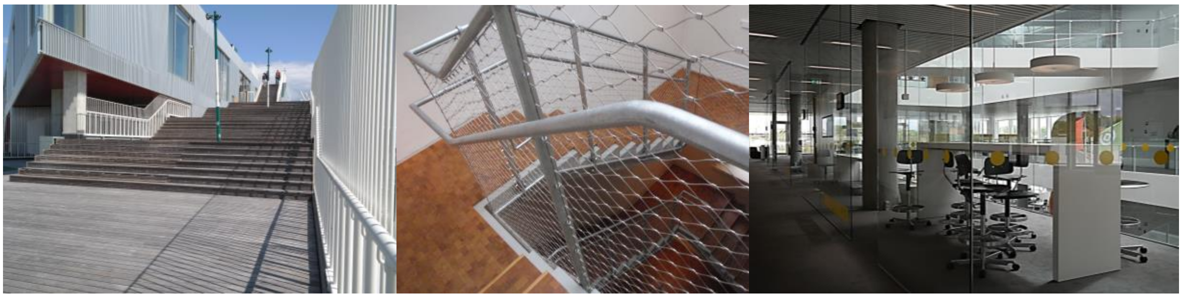

Figure 1 Snapshots from the cases; a public school, an art museum and a university college. Photos: Lars S. Pedersen, SBi.

Another theme was the requirement to a toilet with level access at the entry level of a dwelling. The firm explained that the Building Regulations did not prevent them from installing an extra toilet on one of the other floors in row houses, but it was not cost-effective according to the budget for social housing.

> "… this is a schism because fortunately it is only a tiny part of the population who is disabled. There is still 99,9 % left who can walk on stairs and who finds it attractive to have stairs. That is why there is a problem for us. (…) What I raise objections against it that the excellent Danish tradition of row houses is being spoiled completely." (Group interview with A26)

The possibility of zoning and thereby working with different kinds of accessibility level in relation to the use and the users in a building was pointed out as a possibility for discussing and set priorities and avoid unreasonableness.

> "… if there is some well-chosen spots where you can enter, then it is perhaps okay that you can´t enter through the full range of 20 doors in this building. But if there is five and it makes sense, then it is fine. Then it is possible to prioritise and define the level in general." (Group interview with A31)

Public access was another, but central, parameter mentioned by several firms. Apparently it was easier to imagine a disabled guest than disabled employees.

> ".. and maybe you can slacken some other places. Places where it is not realistic that there is a need for accessibility. (…) in the project XX it makes quite a lot sense to define a higher level than the minimum requirement in the Building Regulations the places where the audiences go." (Group interview with A85)

It seems that the participants were aware of the ethical and inclusive aspect of accessibility and inclusive design but only within limits. When it would be too complicated, they drew a line because of other priorities.

4.3 Application categories and inspiration from a performance framework

It was obvious that fire-safety was a part of the participant's frame of reference, and that they saw a parallel to accessibility and inclusive design. The concept of application category known from fire-safety was suggested as a tool for differentiation because every type of building would belong to a category defining a specific level of inclusive design.

> "Well, you can again compare with the fire codes differentiated according to type of building. There you have six application categories. That could quite easily be applied to accessibility. Obviously, a care home is another category than a single-family house." (Group interview with A82)

The application category is seen as a tool for bringing clarity to the project showing the level of accessibility similar to fire-safety engineering.

> "I think it would be interesting with these application categories as when we start on a project. Then we find out that a nursery, there can´t the user rescue themselves. That implies that we are in a category six and then we know, that we have to follow this." (Workshop)

It was also assumed that a performance framework would create a differentiation in relation to a specific building or a complex of buildings and their function making it more reasonable and support a kind of architectural freedom. A firm was inspired by this concept and imagined that an area of housing could be seen in the lens of a framework. Thus it would offer them a flexibility enabling them to work with a palette of types of row houses with and without a toilet at the entry level.

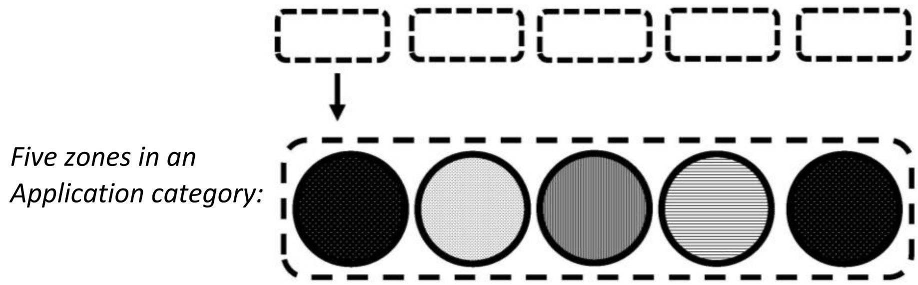

Figure 2 Application categories as a tool for creating differentiation and zoning in a building or building complex because every application category consists of a framework defining different zones and levels of inclusive design.

Initially when a new model inspired by the performance framework was discussed in the workshops, it was emphasised that it could not be a question of obtaining a total score because that would not guarantee a certain level of quality and could result in an absurd situation.

> "I think this accessibility framework is difficult to define if you have to attain a certain score. In other words it can prove when you say that we don´t have room for a lift, it is left out but on the other hand we design two wheelchair-accessible lavatories and 30 disabled parking spaces." (Workshop)

But could zoning and the application categories become a menace or a threat to the quality and the inclusiveness of the architecture? In two of the workshops, the participants brought up that there is an element of unpredictability in architecture enabling future activities that at the moment we cannot imagine. Nobody should limit this capacity and quality by claiming that a place will never be used by a person with a disability.

> "I don´t think that you can specify exactly who is going to use a building. Maybe someone will use the building even through you never had imagined it. Well, what I try to explain is that we should stop saying: nobody who is in need of a wheelchair-accessible lavatory would visit this building; nobody who can´t walk in stairs would visit this building. We don´t know how people look." (Workshop)

4.4 A minimum level

Even though the participants saw a lot of possibilities in a performance-based model, they were also concerned that the client, the developer or the design-build contractor would be unaware of his responsibility. Therefore they argued for a level of minimum requirements. The motives varied. Some firms thought this level would help them in the dialogue with a client, a developer or a design-build contractor to sustain a decent level of accessibility.

> "…for example if you have a developer saying: but, why should we have a wheelchair-accessible lavatory. There should be a minimum to be respected and so that we can document that it isn´t something we have made up, because it is a common requirement." (Group interview with A19)

Another firm wanted this minimum level in order to prevent the players of the field to advance their own cause since the performance-based model would be to open for interpretation.

Furthermore, some participants were fond of the prescriptive requirements because they could respond to them, and consequently felt a kind of uncertainty about a performance-based approach to regulation in relation to their own work practice. Therefore they would accept a new model if they were guaranteed a kind of minimum.

4.5 A new kind of building control

A performance-based model should not stand alone but be supported by a new kind of building control because the participant regarded the practice of the client and the local building authorities as a barrier to a new model.

Therefore it would be necessary to reform the system based on more knowledge because a new model would require a competence boost and a lot of knowledge.

> "We frequently see that developers and the building surveyors as well love the prescriptive requirements because they only have to respond to if a prescriptive requirement is followed or not. In that moment it becomes performance-based, as I think is a great idea, then an entirely new level of knowledge is introduced at the developers and the building surveyors as they are not prepared for today." (Group interview with A65)

A tactile guidance path was an example of the rigid building control. It was difficult for the architectural firm to get permission to use the architecture as a natural guideline or to deselect the standard tactile guidance path. For example, a participant told how representatives from the Danish Association of the Blind had deselected some tactile guidance paths, but the authority claimed they should be brought back to the project. The participant thought it was because they did not dare to take the risk. Another participant experienced that it was a general tendency that these tactile guidance paths had been put on squares just in order to be safe – to wear both belt and braces.

Apparently the participants question the quality of the building controllers' competencies. A firm suggested that the need for a new procedure for building control together with a new culture. Accordingly, a new model would require an open-minded approach to the building control because it would be more complicated without the prescriptive requirements.

> "If a performance-based model, then the building surveyors should be prepared for letting it go that it is not an article that should be meet by an exact measure. When is something met? (…) I think that at any rate a way of managing this challenge should be developed at the building surveyors…." (Group interview with A82)

Table 1 Prescriptive requirements versus a performance-based approach

Prescriptive requirements	A performance-based approach	
Simple; only threshold, heights, ramps	Flexibility	
Too homogeneous - absurd	Differentiation	Zooning
Unreasonable	Application category	Framework
Security – wear both belt and braces	A minimum level is required	
Easy to control	Knowledge and competence boost is required	
Rigid building control	An open-minded approach are required	New culture

5. Conclusion and discussion

Aiming at a more innovative and inclusive architecture, the empirical material has revealed an interest in a performance-based model instead of the prescriptive requirements of the current Building Regulations.

The concept of the framework should guarantee a possibility for differentiating within reason, described as zoning and application category due to the specific project; its size, function and user group. Where the prescriptive requirements will often lead to rather standardised solutions, a performance-based model is considered more flexible giving possibilities for designing new innovative solutions tailor made for a specific building programme and context. Nevertheless some of the participants see a risk of not prioritising the accessibility. Consequently they endorse a minimum level in a future model. The performance-based model with a minimum level represents a paradox. Because on one hand, the firms assume that such a model will create a kind of architectural freedom but on the other hand the minimum level would impose a kind of restriction on architectural freedom.

We have seen how the professionals are questioning the building control system, but without questioning their own practice and level of competences when it comes to inclusive design; the perspectives of the users, equality as a design parameter etc. They found that a new model would require another procedure, culture and a boost of competencies at the local building authority.

The requirements of the Building Regulations can be characterised as context-independent. Especially the prescriptive requirements are context-independent because they are applicable in any situation. But when the participating firms in this study demanded differentiation as an individual point of departure, it can be considered that individualisation tends to a more context-dependent approach. But we do not know enough about what this tendency actually entails or requires from all the actors of the network of regulation. It would presumably require a shift in work practice and more knowledge.

But we can ask whether a performance-based model would create more inclusive architecture? Presumably not, because this study indicates that the architectural firms' view of humanity and view of users are quite rigid. It is accepted to talk about that not everybody should have access to a roof terrace. Furthermore the view of a disabled person is very limited. As an example, nobody imagines that a disabled person could work backstage at an arena. This attitude will probably be transferred to the work within a new model.

Fire-safety has emerged as a consequence of the performance-based codes and has changed the practice of architecture. Similar to fire-safety engineering, inclusive design could emerge as a field architects could be specialized in order to create an innovative and inclusive architecture where the accessibility is integrated in the architectural idea from the start as a driver. But it would require a shift towards a more comprehensive understanding of ethics, equality and the users' perspectives. More knowledge about the specific context could be attained in a more user-centred design process.

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Hidden public spaces: when a university campus becomes a place for communities

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Abstract: "C'è spazio per tutti/There's room for one more" is an event that took place in November 2011 at the Milano Bovisa Durando campus of Politecnico di Milano, Italy with the purpose of opening up the public spaces of the university to the inhabitants of that area through a series of design actions to offer opportunities for understanding, observation and enjoyment of a public space. That was the beginning of a series of design for social innovation projects connected to the Bovisa neighbourhood organized over the following years. In this paper we will describe the need to open-up hidden (unknown) public spaces like the Milano Bovisa Durando campus and the idea that through small rapid design experiments we can immediately test the efficacy of tools made to enable people's and communities' use of the public space.

Keywords: Hidden public space, Toolkit, Communities, University campus

1. Introduction

1.1 The city and the need for communities.

The activity of communities in public spaces is a key feature of moving towards a more sustainable way of living in the urban area. It is not surprising that the city has been a favourite discussion topic (for bad or good) in the recent years, and for a good reason: the world's population is becoming concentrated in urban areas; therefore, taking care of the city means taking care of large numbers of people. The common image of the expanding city, however, is far from ideal. The most frequent words describing urban realities are: social exclusion, alienation, segregation and loneliness. More than a crisis of the city we should rather talk about a crisis of city life. Globally, cities are growing, changing and developing, and international metropolises share more features than they do with their local contexts (Sassen, 2004). It has been clear for some time now that new development strategies are needed, but: where to begin? In the United States many authors have criticized urban planning processes and accused them of not considering the residents' needs, some offering concrete solutions and alternatives. In 1970, Richard Sennet (Sennet, 1970) wrote about the crisis of the city, introducing an idea that differed from that of Jane Jacobs in *"The Death and Life of Great American Cities"* (Jacobs, 1961). Jacobs, he says, is nostalgic about the past and the relationships between people in small towns; she tends to suggest a restoration of past conditions. Sennet (1970) states we can not think that the past can give us elements to improve our present city problems, as the solutions we want must be adapted to an affluent, technological era. The answer is probably to be found between these two arguments, or perhaps they are not so far away from each other to begin with. They both conclude that communities must have a need for, and the will to re-reach some values that have been lost in modern urban life, such as mutual support and conviviality. Although written some years ago, these books still represent important and contemporary criticisms of today's urban planning. More and more people in cities are finding creative ways of refilling those gaps. They collaborate in various ways using new and old tools. These creative communities (Meroni, 2007) are producing social innovation. They are a sustainable resource that must not only be recognized but also supported and disseminated. According to Manzini (2015), "social innovations are solutions based on new social forms and economical models. They are those social changes towards sustainability when they can reduce the environmental impact, regenerate common goods and social fabric". These innovations often deal with public space because communities often act in and for public space. What kind of public spaces and how they are connected with the university realm is the key issue to be discussed in the next paragraph.

3.2 Space for urban communities

Independent events have started to grow in the city, in those areas where there are particular problems which are shown by increasing the consciousness of the residents (Bostjan, 2010:22). The city is read as an independent container of public spaces even if, according to Rem Koolhas, the distinction between public and private is nowadays out-dated. We are faced with residual spaces, abandoned and not controlled. Giovanna Piccinno in *Space Design* (Piccinno, 2008, p.11) says that "[…] the contemporary designer must listen to new places (without distinction between places and non-places) and new citizens (local or itinerant) and answer in terms of design with the operative tools he has.[…]". The action is generally done in places which are not offered freely or donated, but, on the contrary, are lent or temporarily given for a specific use (Haydn and Temel, 2006). And we are not only talking about those places recognized as possible sites for temporary urban solutions (Fassi, 2012)[1] (squares, parks, stadiums), but about those areas at the margins, which have been

[1] "Temporary urban solutions" (TUS) are project answers put in place by professionals in a sector or by groups of people lead by a team of
project specialists, which change into devices, set up, collective actions, emergency displays, project strategies which contaminate the single building, an agglomerate of them, a urban interior or an open space or a passage space with a

stolen from an inattentive urban planning project or infrastructures that do not enter into dialogue with their context (Navarra, 2008).[1] Or it is the “space of abandonment” as the “Stalker” group defined it (Careri, 2006), which is a space “where complexity survives to the mono-functional colonization and the city experiments generating a neutral area which gives back a sense of concept to public space as a creative space and sharing space” (Romolo, 2005, p.18). Luciano Crespi (Crespi, 2009, p.20) says that the “true act of recognition of the place is only through the presence on the place itself, within the internal and external areas, whose changes need to be foreseen. Where staying means something deeper than stopping for a moment or being there by chance. Staying means the need to understand, to listen to the place, to recognize the soul” in the sense provided by Hillman (2004). The sense of ownership of space reflects the reading of the city as a “place of self-identification of the individual” which, according to Barcellona (Barcellona, 2006, p.17) “is possible through the personalization of the urban space which is at the same time the structured image of values and community bonds and the place of distinction for the relationship between single and community”. Feeling an urban space means perceiving a shape of what is empty and what is full, of high and low spaces, above and below spaces, but also recognizing a system of relationships between the people who live in these spaces, the neighborhood, the life in the residential areas, true centres of communication (Barcellona, 2006, p.17).

As Francesca Zajczyk states, the neighborhood is a portion of an urban area, both physical and social, where plenty of resources, factors and critical situations can be found. It underlines the identification with the local side of the city, is able to read the micro-social dynamics and to express the relationship among citizens/social groups and urban areas (Zajczyk, 2008).

2. Hidden public spaces

Sometimes public space is not obvious. When the borders between private and public are blurred, new kind of spaces are born that even if they belong to everyone they are not visually public. These are public spaces we define as ‘hidden’. Traditional houses and apartment blocks in Milan were designed to have an inner courtyard that generally gave access to other buildings inside, but is not seen from the outside. These courtyards have direct access from the streets that brings the user to a semi-private area. It means they are open to the public even if they belong to a private property. It is this feature that makes them hidden places, since citizens, tourists or casual passers-by are not directly aware of them and could only discover them if needing access. This courtyard distribution system comes from the farmhouses (“cascina”), a traditional system of buildings, now found only in

process of functional and perceptive change on the occasion of temporary events linked to hospitality, to sales, to leisure time, to entertainment” in Fassi, D., Temporary Urban Solutions, Maggioli, Rimini, 2012, p.12.

[1] “Infrastructures compose an articulate vocabulary of shapes which defining the covered spaces with a variable height, interfere with the urban network. Thus there are some special points which form residual spaces, not accessible to cars and separated by houses. In these knots there are the spontaneous and temporary actions which bring to their use with absolutely variable ways and time”, Navarra, Marco, (a cura di), *Repairing cities*, Siracusa, LetteraVentidue edizioni, 2008, p.14

the countryside close to Milan, which serves both residential and work purposes. In Milan we may find “a city within a city”[1] made up of these hidden places: some are unknown even if located on main urban pathways, other are invisible because they are located in an urban “backstage”. They may be classified as those that have a cultural heritage value (material or immaterial) and as those that have potential to be explored and valued in a community. Public university campuses are included in this latter category. Even if they are used by a specific kind of user (people who study or work there) and are perceived by other people as a private area (belonging to university); in most cases, however, campus spaces are public. According to Zukin (Zukin, 1995) “public spaces are important because they are places where strangers mingle freely” and since “metropolitan universities offer the possibility of creating a dialogue across the difference that largely defines metropolitan life in our time” (Bender, 1998) we may consider the campus located in the Bovisa area in Milan as an example of how this dialogue could be developed by merging the neighborhood and the academic staff. The crucial location of this campus is described in the next paragraph where a strong connection among spaces, buildings and communities emerge.

2.1 The Milano Bovisa Durando campus

Bovisa is an ex-industrial district. In the second half of the 20th century it was subject to great change due to the removal of almost all the industries. The district was left with many abandoned areas that were soon to become a problem for the residents as they attracted homeless people, drug dealers etc. The quarter had lost its main reason of existence and did not initially transform into a suitable residential area with appropriate public spaces. The population has become more and more mixed as immigrants came to the district. Various re-construction projects slowly began in the area and the biggest one was the creation of two university campuses for the Politecnico di Milano, Milano Bovisa Durando and Milano Bovisa La . The arrival of Politecnico di Milano in the Bovisa area changed the district again, bringing in young students and commercial activities related to them. The new life of the neighbourhood has indeed brought an improvement of public transportation and the building of new residential areas, but public spaces like green areas or squares with street furniture are still missing. The Milano Bovisa Durando campus, hosting the School of Design, was built at the end of the 90s on the grounds of “Ceretti & Tanfani”, a long-established company that had produced cable railways and had made Bovisa a working class district. The place is part of the historical memory of the local inhabitants. Today it is a green space with places to sit as well as a cafe. In spring and summer many students sit outside, enjoy the sun and doing outdoor activities. It is a hidden public space since no one beside the university community uses it as such. The campus remains an “island for students” and most of the people who once knew the place as a former industry did not even have the opportunity to see how it has transformed. The two types of ‘users’ (university community and the local

[1] The hidden Milano is now at the centre of a tourist promotion activity by the city council. It is described in detail at www.turismo.milano.it

residents) have very few contact points in common. The potential for improvement the campus could have offered is huge, but unfortunately it has not been fulfilled.

3. Hidden public space and design education experiment

Following the premises described in the previous paragraph, as a research team dealing with design for social innovation, we started to investigate how this hidden public space could have been opened up by the university community (students/designers/staff) to create extra space in the everyday life of permanent residents. To answer this question we tested a design education experiment based on user/community centered design, using co-design methods and creating a deep immersive experience in the neighborhood for postgraduate students. We embraced the theory of designers as solution-developers for people to one that allows people to design by and for themselves (Brown, 2009) asking the students to open a dialogue with the local community, with associations or informal groups. In 2011, when we established a workshop at the School of Design this offer was addressed to postgraduate students from MSc Interior, Communication. Fashion, Product Service System and Product Design. This created an intra-disciplinary class that was useful to merge skills, competences and approaches since the students were working in teams. It was the first time that a course with a strong connection with the neighbourhood and with a deep in-the-field immersion was held at the School of Design. At the same time, a Polisocial programme was starting: a programme for university social responsibility. Polisocial aims to place the university in close contact with the dynamics of change in society, extending the university's mission to social issues and needs that arise from the region, on both a local and global level. Polisocial promotes and encourages new multidisciplinary approaches in human and social development, developing training opportunities and opportunities for exchange and research offered to students, researchers, and the university's teaching and technical-administrative staff. "The goal is to foster a responsible attitude and to develop skills, expertise and new values, in future generations of professionals and citizens, increasingly more aware and prepared to handle ethical challenges" [1].

3.1 Methodology

A Participatory Action Research (PAR) was used to define the workshop activities. At the heart of this process is five-day workshop for design students ending in a one-day event to test the ideas immediately. Since a prototype can not only be viewed as a thing (an object) (Anders et al., 2011) but also as socio-material relations where matters of concerns can be dealt with (Björgvinsson et al 2010), we encouraged the students to work on both these features. That is why the prototyping action was connected to an event where not only product/spaces/service are shown and but where relations take place helped by the use of toolkits. The toolkits are made to be used directly by the end users, thus empowering them to develop certain actions or to achieve specific goals. This kind of fast, small design

[1] http://www.polisocial.polimi.it/it/home/

experiments allowed us to reach quick conclusions and continue towards more stable and organized solutions (Fassi, Meroni, Simeone, 2013). Our PAR process was organized in this way:

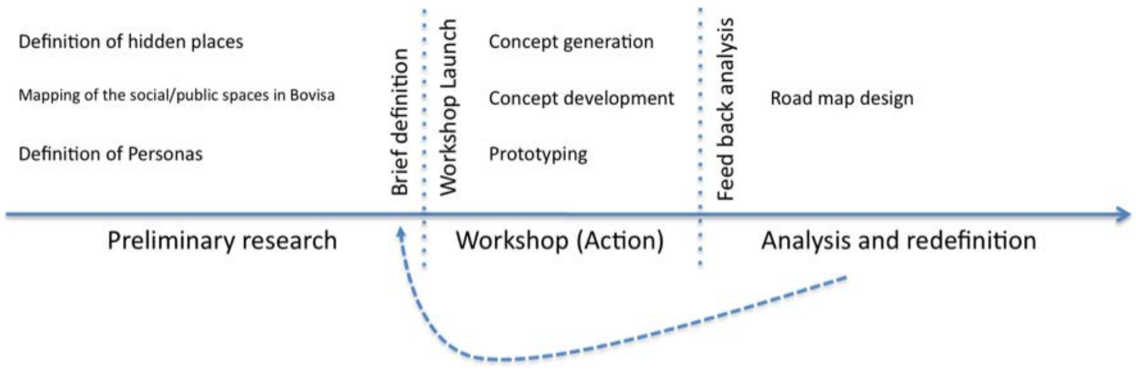

Figure 1: PAR (Participatory Action Research) Model

The research began with a preliminary study of available literature about conventional and non-conventional public spaces. Through this, a definition of hidden public spaces was made available (see above). The Campus Bovisa area was then chosen in order to generate an applied activity on the topic. The second part of the preliminary research is context-related and included the definition of personas and the mapping of the area's social places.

3.3 Mapping of the social/public places of Bovisa

An immersion took place in the social/public places of Bovisa, including schools, local associations, public services, libraries, parks etc. From this mapping it became clear that public areas that involve the whole community are missing and the existing social places are related to specific communities and are semi-private. Some of the hypotheses previously formulated were confirmed by this phase of the research: the Milano Bovisa Durando campus is not considered a public space for the residents and there is a vast interest in having more space available for age- and culture-crossing activities. Also, the campus is very intriguing for the people and most of them, especially the retired people, expressed a need and real curiosity in seeing what Politecnico di Milano is and how it uses those areas. Most of the new local shops that were opened after the arrival of Politecnico di Milano are used by the university community and experience a loss of customers at weekends when there are no activities in the campus.

The research and mapping brought a definition of the brief to the student workshop. The students were asked to:

- develop ideas for collaborative services on the campus area for local residents
- design a toolkit to enable people to participate in/initiate the services

- test part of the toolkit or prototype the service where needed, in the one-day event scheduled after the workshop.
- let the people do social activities in a "design context" (i.e. School of Design spaces of the campus)

A few more specific topics emerged from the first part of the research: 1) the lack of green spaces and the relationship with nature, 2) the absence of a cultural heritage related to everyday spaces 3) the desire for a sense of community and the need for dedicated spaces, and 4) a constant need to re-vitalize the neighborhood from a cultural point of view. These results produced four topics that were presented to the students by the tutors as part of the brief:

- Food: green spaces, contact with nature, cooking
- Places: local cultural heritage valorisation, explanation of Politecnico di Milano facilities
- Free time: public sport facilities or spaces, spaces for group activities
- Entertainment: events, exhibition, open air activities.

4. The workshop

4.1 Concept generation for services, concept development:

42 international students joined the workshop as an elective course on the MSc Product Service System. Students were asked to split in teams and work on one of the four topics assigned. One team focused on managing Saturday morning events, including communication strategy, fund-raising to produce toolkits, logistic issues and promotion/advertising to guarantee an adequate number of people would attend. On Wednesday the event-managing team went to the local market to promote the Saturday event through a flash-mob that focused on the idea of providing a chair for people to come and sit with them to have a chat in a public space. It was a way of letting local people know that a "hidden place" was asking to be discovered.[1] During the week the same team went to the mapped schools to advertise the event to the children and to their parents/grandparents at the end of the school day to spread the word. Small groups of students worked on concept generation for the first two days and then moved on to the development of the project and the production of the "material" outputs included in the toolkits. Five concepts were presented according to the topics suggested and the "personas" identified. Workshops with children, gardening, tours of the campus, and light sports activities were some of the visions designed by the students that received detailed feedback in a session where students and tutors were to produce five projects to be developed in the following three days, which would then be presented at "C'è spazio per tutti/There's room for one more" event. During

[1] Short movie about the flash-mob can be viewed at http://www.youtube.com/watch?v=PzyhIXTBhD8

the second part of the week there was a huge effort by the students to get in contact with local shops for the supply of raw materials that would useful to the projects.

Five toolkits were designed for the five outputs of the workshop:

- “C’è giardino per tutti/There’s a garden for everyone”: to create a urban garden for the area in the green spaces of the campus. A community garden inside the Politecnico campus would enable people to create a community, enhancing trans-generational exchange and promoting a sustainable lifestyle

Figure 2 “C’è giardino per tutti” toolkit

- “Il mio taccuino/My notebook”: to introduce the natural part of the campus to children through collecting leaves, drawing and using the “frottage” technique. The main purpose is to let children understand what the design process is through a series of guided exercises inspired by our activities. As well as new techniques, the children will learn how to discover new places and know more about specific contexts by using a different approach.

Figure 3 Il Mio taccuino toolkit

- “Piccoli cuochi/Little cooks”: to apply the design process to cooking according to Enzo Mari’s theories, involving children. It encourages people to get to know each other and collaborate while being engaged in a cooking process which reflects the design method. The toolkit includes: 20 cards – ingredients, 20 cards - cooking utensils, 1 instruction card with rules of the game, 1 method card with recipe.
- “Poli-tour”: to discover the past and present of the campus, through some traces left by the former factory “Ceretti&Tanfani” and discovering the facilities of Politecnico di Milano. The toolkit is made up of 6 elements: a map including clues to find the path of the quest; information postcards and photo panels, providing information about the past history and the present of the campus, the red chair where people would sit and have a picture taken in the campus context.
- "Peter e Gisella": to reclaim the public space through light sports activities linked to campus areas (fig. 4). The toolkit includes 7 illustrative boards, which can be printed to create different areas where participants do different healthy activities, magenta stickers to indicate where the activities take place, and moustache stickers for the laughing activity. Users can also add new activities to customize it to their own wishes.

Figure 4 "Peter and Gisella" toolkit

4.2 Prototyping of service ideas

Some guidelines have been followed to prototype the toolkits to guarantee scientific results. First: the toolkits had to present as a physical output including the rules and tools to be used. Second: the toolkits had to be produced in a series of fifteen items (as a minimum) to allow appropriate sufficient number of people to be involved in testing them. Third: three to four facilitators had to be present to help users engage with the toolkit and use it. Fourth: the facilitators had to collect feedback directly (through an informal conversation with the users) and indirectly (through observation of the interaction between users and toolkits). Fifth: every activity had to be recorded through pictures and/or movies.

When the gates opened a reception desk was placed at the main entrance and the event managing team was in charge of welcoming the people and explaining the project. People of the neighborhood were invited to use the space (often for the first time) as a public space and they were given a map of the campus, including where they could find the toolkit to be tested.

4.3 Feedback.

200 people entered the campus that day and the general feedback was positive. Feedback was collected by interviews, surveys and active observation on the day. The surveys/interviews asked mainly:

- if people could see themselves coming more frequently to the campus to use it for their own activities or enjoying the activities provided
- their opinion about the one-day event and the individual activities
- their wishes for future events in the campus

Active observation, including taking photographs and filming, was important in understanding different behaviours. The students could immediately understand if there was something in their project that needed modifying and some did it on the same day to have immediate results. Others took notes for a future design of the project. [1]

5. Analysis and road map design

The feedback was analysed into points of strength and weaknesses (as described below). In order to achieve continuity and arrive at a repeatable model we designed a road map for future steps.

5.1 Results

The overall results of the research have shown:

- Interest by the people to discover the campus as it is today. Many of the visitors knew the place in it former use and during this event had the chance to see it for the first time as a university campus. Elderly people were very keen to see the transformation and tell the students about what used to be there before, having a real wish to strengthen their memories.
- Understanding by the people of the new opportunities offered by the space (how they can use them). Entering the campus and participating in the initiative made people understand how they can use the space on an everyday basis. Many people showed interest in coming there with children to enjoy being in the open air or ride bicycles because the space is well-protected. Also, people involved in local associations were interested in initiating their own activities in the space. A group of neighbors was interested in maintaining the vegetable garden and creating a new green space for the neighborhood, as they do not own a private one.
- A better understanding of the local context by the university community. The event allowed the university community to know more about the context (and not only the limited places where they have lessons)

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[1] A short movie about “C’è spazio per tutti/There’s room for one more” made by the event managing student team is available at http://www.youtube.com/watch?v=atvk7kw5_Ic&feature=related

- Offering a mixed space for several categories of users. The Bovisa campus space was transformed by the designed toolkits into a multi-user space with very different activities. The people participating noticed this and the feedback was very positive.
- Generating new economic dynamics among local shops, citizens and students. The fund-raising done by the students among the local commercial activities allowed them to become acquainted with the economic (and not only social) potential of the event. Those who understood the potential of collaborating with the university showed great interest, and availability and connections were made for future projects.
- Limited time of the event. 3.5 hours is a rather limited time for an event. On one side it allowed us to achieve a good level of results and tests but, on the other, it could have been longer and lasted for the whole day so as to not only get in touch with the "morning" users of the area but also with the "afternoon/evening" ones.
- Campus boundaries. Politecnico di Milano campus has physical gates that are perceived by residents as a barrier. This created some difficulties during the event, because, even if they were open and advertised as the entrance, they were still perceived as a restriction to accessibility.

6. Follow up and discussion

6.1 Follow up

The need for spaces for the community in the city was confirmed by our PAR. According to certain targets set in the goals, the results of the "C'è spazio per tutti" workshop and event have generated scenarios that could be systematized to give the prototyped solutions a temporal continuity and interaction by generating new solutions for integration with the space. The time pattern in which the research/action was set, has been effective because there was an area of direct consciousness as to the failure or success of the project. The workshop, thanks to the Masters level students, a good mix of background and skills of the team members, and to rhythm and aims set during the initial phase, was a research method with a high level of instantaneous experimentation generating ideas to be put into effect. It soon brought results thanks to a rapid phase of development.

The hidden place started to be discovered by the neighbourhood. The depth of existing boundaries between the university area and Bovisa was decreasing through word of mouth and signals left on the campus as a memory of the event.

"C'è spazio per tutti" gave rise to several subsequent initiatives. The format we used was so successful, both in terms of the quality of the solutions and of the number of citizens involved, that we decided to use it as a model to be repeated. In October 2012, we organized a second version, where we proposed ten different design activities with the result of opening up the campus to more people.

In 2013, the name and format changed due to a systemization through a Masters thesis in Product Service System Design[1]. In March there was the first "Il Sabato della Bovisa" (Bovisa Social Saturdays) to further underline the context of the Bovisa district, where it takes place. In that year the event became a monthly appointment for the campus by a regular involvement of the local associations to gather more people. The format was repeated for five months (from March to July 2013) with four main activities focusing on book sharing, children's games, gardening and light sports activities. It was then held twice in 2014 and in March 2015, where it was doubled (over two different days) and took place not only in the Bovisa campus but also in another hidden public space of the neighborhood (called Bovisasca).

6.2 Discussion

The main characteristics of this format are, first of all, the relationship between the campus and its neighborhood, and then the focus of the projects: all are toolkits designed by the students with and for a local association; and again, the temporary nature of the format.

The success of these events can be seen by their numbers: from 250 visitors in the first edition in 2012 to 750 in March 2014. This underlines the results of making a hidden public space more visible to a larger number of people by using design actions.

This result is not only connected to the individual events but it also has a long-term application. One of the projects designed for the first event (C'è giardino per tutti) was carried forward and became a permanent project: *Coltivando - L'orto conviviale al Politecnico di Milano (*Coltivando - The convivial garden at the Politecnico di Milano).

Coltivando was the result of a deep research on the urban agriculture topic within a public space and of a co-design process, lasting four months, which brought people back to the university campus more regularly by involving them in continuous activities (set-up, maintenance, etc.) in the garden. *Coltivando* was founded in October 2012 by a group of professors, researchers, and graduates of the Department of Design, and the School of Design of the Politecnico di Milano. Its main objective is, again, to connect two spatial and social entities that co-exist but do not connect with each other through conversation: the Durando university campus, established at the end of the 1990s, and the surrounding neighborhood of Bovisa. After more than two years, the garden is a thriving hub of community activity, and is considered a success. The team of organizers is made up of 15-20 participants from the neighborhood.

These two initiatives, a temporary event and a permanent community garden, generated awareness in the local neighborhood of the role of the campus and the university. But how could these projects become economically sustainable and/or adapted in other similar contexts?

This question is at the core of "campUS" – Incubation and Settings for Social Practices", a funded research project financed by the "Polisocial Award", a prize that awards social

[1] Roberta Motter, Il Sabato della Bovisa, MSc Product Service System Design thesis, Politecnico di Milano, 2013

innovation research projects within Politecnico di Milano. The project encompasses four different initiatives: the drawing up of guidelines for the design and the realization of urban community gardens, a neighborhood social TV network, a traveling pavilion to host the activities of the local associations; and the study of the economic sustainability of the three preceding initiatives. This research project is currently ongoing and underlines how the role of the designer as activator can enable people to live and use spaces on their own. The expected results at the end of the project (October 2016) will be a model of economic sustainability that will allow the outputs (community garden, social TV and traveling pavilion) to continue for a longer time.

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